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THE VICTORIA TORPEDO.

THE ordinary Whitehead torpedo, such as is used in our own and every other naval service, except the American, is a missile weapon. Once the firing trigger is pulled all control is lost of it, as completely as it were a shell. It goes forward, impelled by its motive power and subject to be swept to one side or the other by tides, currents, or waves, and if it is fired from the deck it goes from one moving object to another, while if it be fired from beneath the water line the ship has to be expressly steered for that purpose, and an allowance made for the speed at which the ship is going, which must be more or less a guessed at quantity. Even if it be well aimed and runs its course without deviation, it is possible that the ship against which it is launched may have moved away before it has time to strike, unless the range be very short. Of course with shot and shell it is only expected that a moderate percentage of hits will be made, but with a weapon costing some 300*l*., and of which only very few can be carried, the percentages of hits must be greatly increased in order to make them effective; for at each shot a portion of the ship's armament is irretrievably lost.

It is well known that many inventors have turned their attention to the problem of controlling a torpedo all the time it is in motion—in fact, of steering it from a distance. If this could be done successfully—that is in a way compatible with the exigences of warfare, and not merely as a peace experiment—it would introduce a new element into naval combat that would entirely change the present system of attack and defense. The captain of a vessel would then have at command a flotilla of high-speed submarine boats in which there were no crews to be considered, and which could be let loose at an enemy in sufficient numbers that would prevent all chance of escape. It is fortunate for those who follow the profession of fighting that new weapons, whether they be mitrailleuses, torpedoes, or automatic guns, never prove so destructive as they appear on paper. Means of defense and improvements in defensive tactics never lag far behind new means of offense.

The latest improvements in controlled torpedoes are due to Mr. Read Murphy, of 34 Victoria Street, Westminster. Mr. Murphy is a resident of Melbourne, Victoria, and has named his weapon after his colony. It is constructed in two types, designed respectively for use from shore in the defense of towns and harbors, and for use from vessels and torpedo boats. In all essential respects the weapon is a Whitehead torpedo. It is of the same general shape and construction, and is propelled by compressed air in the same way. But to the Whitehead equipment there are added some new features of great importance by which it is controlled. The steering devices are found in both types of weapon, but in the shore torpedo there are provided means for stopping, starting, and exploding at the will of the operator.

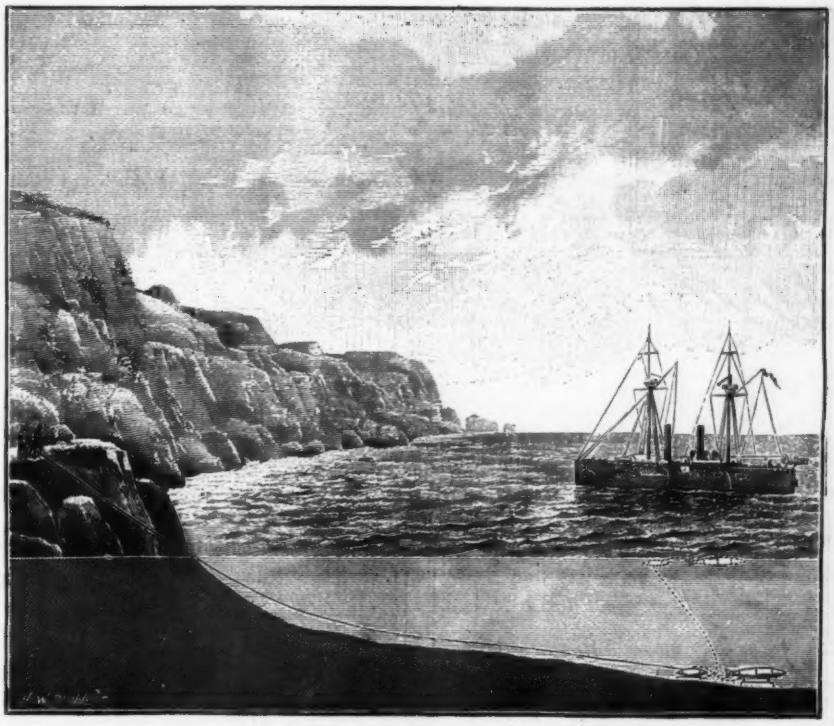


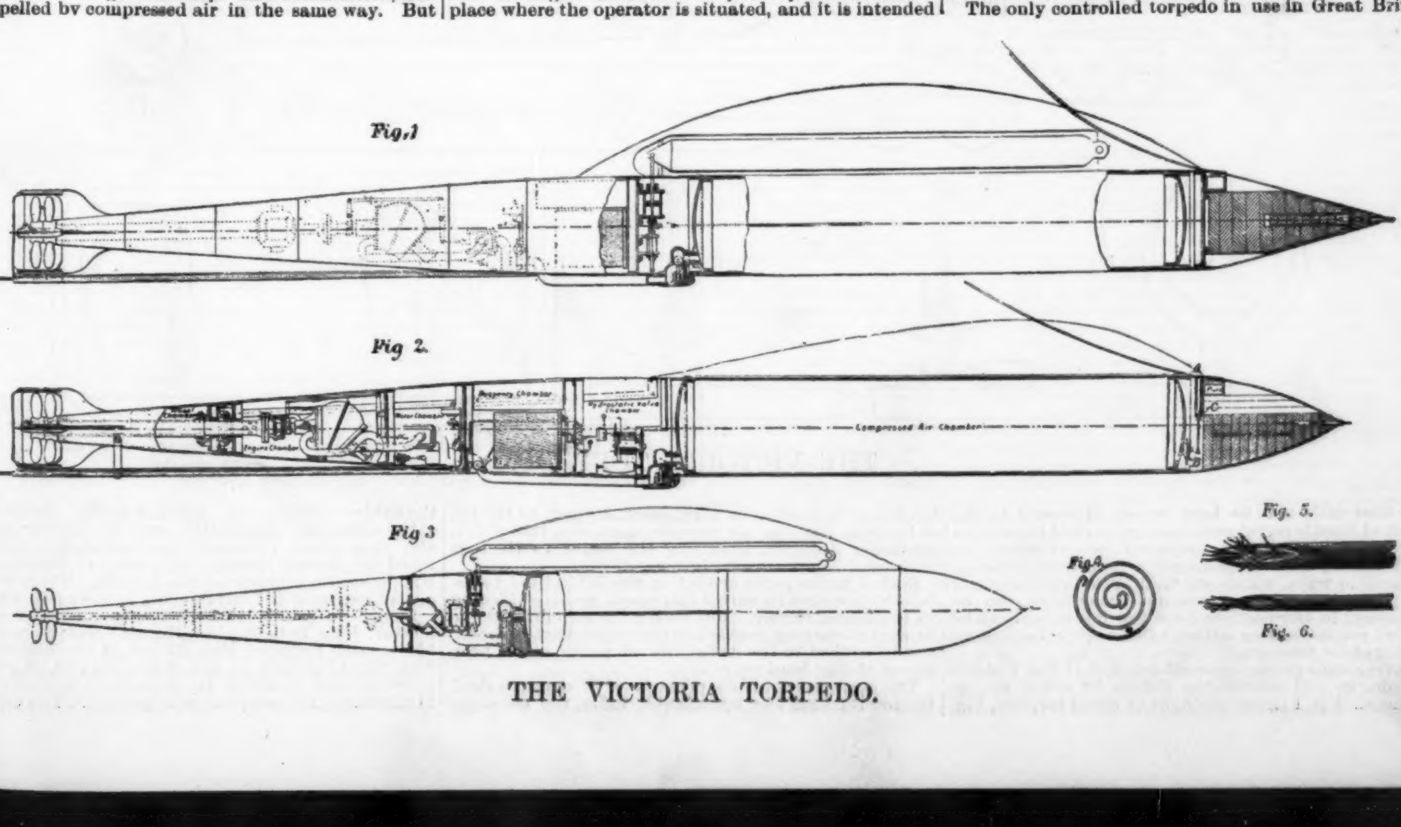
FIG. 21.—THE VICTORIA TORPEDO.

As the shore torpedo is the larger and more important of the two, we will describe that first. It is 24 ft. long, and 21 in. in diameter at the largest part. The head carries the charge; next comes the compressed air chamber; behind this is a chamber in which are coiled 1,200 yards of electric cable inclosing the insulated copper strands; further aft again is a chamber in which are three electrically controlled spring motors, one for working the vertical rudder, the second for the air valve which controls the propelling engine and allows the cable to pay out from the torpedo when at full speed, and the third for exploding the torpedo and also for bringing it to the surface. It is through the agency of the cable and the motors that the torpedo is controlled. The 1,200 yards coiled within it, however, do not represent its range. An additional quantity is coiled at the place where the operator is situated, and it is intended that this shall be drawn upon first. As the speed of the weapon is under control, it will be seldom advisable to launch it at full velocity. The amount of power required to drive it at full speed for, say, half a mile would propel it for several miles at half speed, and hence it would usually be wiser to send it away at a moderate rate until within easy shooting distance, when full speed can be given if desired. During the first part of the time the torpedo would be dragging its cable behind it, not a very serious matter, since it only weighs 41·110 grammes per yard in air, and when greased, it will leave the torpedo 22·312 in water. But when the air valve is opened wide to give full power, the coiled cable is released and pays out from the body of the torpedo, thus obviating the drag, and giving 1,200 yards free run. There is also a device provided whereby, should the shore end of the cable become fouled, or offer too much resistance to the motion of the torpedo, the clip which holds it is tripped, and the cable within the torpedo is paid out. In the present case the course of this torpedo will be shown by Holmes' compound, the gas from which is forced to the surface by the rush of water through a tube, but the ordinary means of showing the course of a torpedo may hereafter be adopted.

For shore stations the Victoria torpedo, instead of being launched in the usual manner, may be deposited with a buoy in a cage under water, it may be a mile or more from the shore, and is there left until the enemy appears, when it is released. On being released the buoy ascends a given distance, and the torpedo starts on its journey, pulling the cable from the buoy as it would from land. As the buoy contains the cable that would be otherwise wound at the sending station, the torpedo has its run of two and a half miles from the position of its cage, and is worked from this point exactly as it would be from land.

An ordinary cable connects the torpedo cage with the operating station on shore. This cable contains the three strands already described of an extra stoutness to carry the extra electricity and two extra strands, one of which enables the torpedo and its buoy to be released at pleasure, and when not required for this purpose is connected with an ordinary electric bell. The second strand is connected with electric cells, so that if the torpedo or the cable is interfered with by the enemy, or hurt by mischance, the water will connect the two strands so that the bell will ring, and the officer instantly be apprised. If, however, all goes right, he can, by a touch of the key, open the cage and liberate the torpedo, which will rise, as described; its engines can then be set in motion, and it can be controlled and steered at will.

The only controlled torpedo in use in Great Britain



THE VICTORIA TORPEDO.

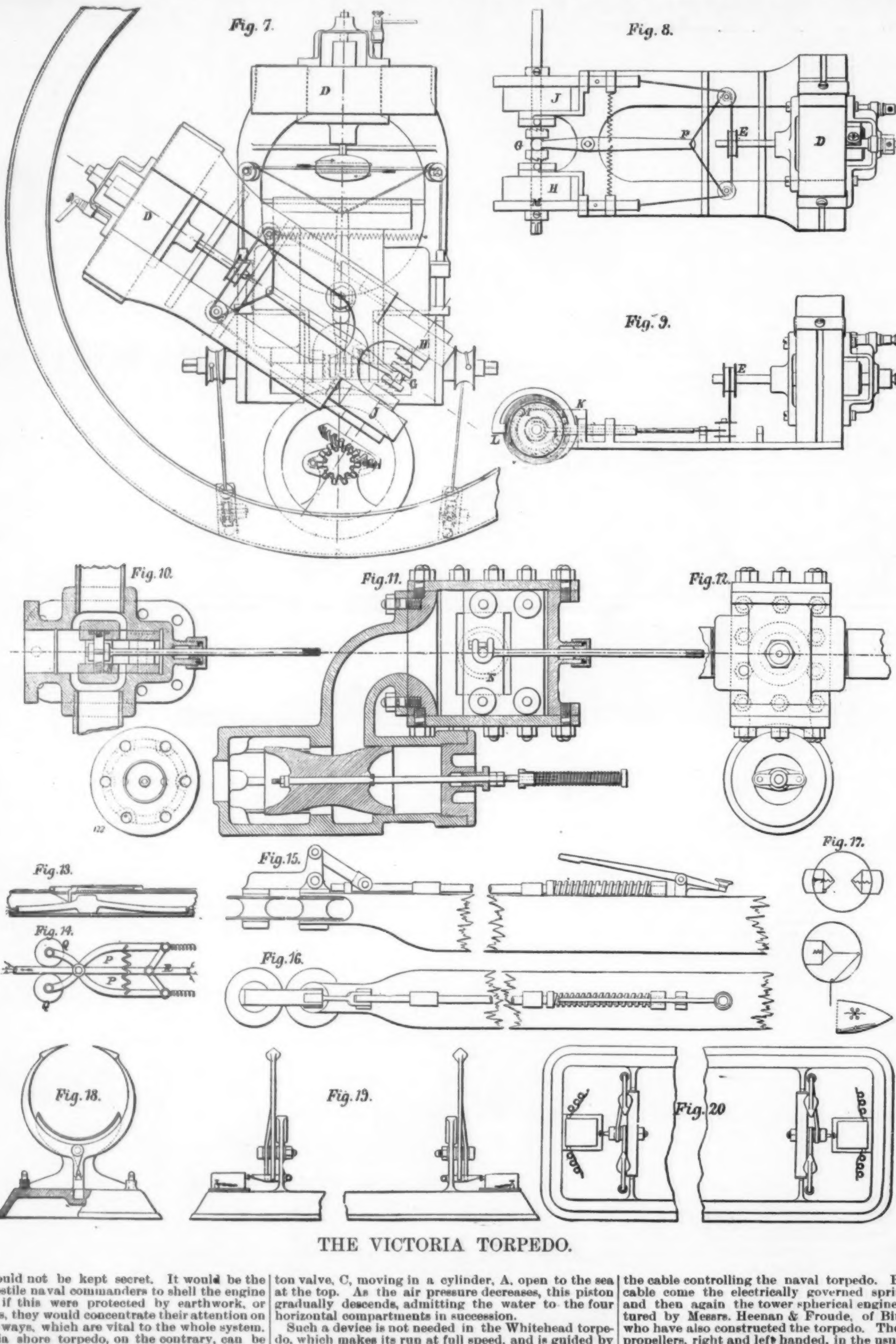
is the Brennan, of which we gave an account, pointing out that the government had paid a very large price for a weapon having many inherent disadvantages. This torpedo requires a powerful steam engine and boiler erected on the shore very near the launching point, and, therefore, it requires a long time and many expenses for its installation. The exact position of each Brennan torpedo would be known, and an enemy's ship, in case of war, would come prepared with the knowledge. Even if new installations were made after the declaration of war, it is more than probable that their sites could not be kept secret. It would be the object of hostile naval commanders to shell the engine house, and if this were protected by earthwork, or fortifications, they would concentrate their attention on the landing ways, which are vital to the whole system. The Victoria shore torpedo, on the contrary, can be submerged in any position in a few hours, and can be started on its course without the enemy having an inkling of its presence.

Having thus given a general account of the Victoria torpedo, we will describe the details by aid of the engravings. Fig. 1 shows the light or naval torpedo, Fig. 2 the shore torpedo, and Fig. 3 one form of its float. In Fig. 2 the various compartments are marked with their respective names. At the head is the explosive, this being stored in the lower part of the chamber. At the upper part is the receptacle for Holmes' fluid with a pipe for its delivery passing up the dorsal fin. A part of the forward compartment is left vacant, and is intended to be gradually filled with water as the compressed air is expended to replace the place of the latter. Connected to the forward bulkhead of the air chamber is a diaphragm, B, coupled by a rod to a piston valve, C, moving in a cylinder, A, open to the sea at the top. As the air pressure decreases, this piston gradually descends, admitting the water to the four horizontal compartments in succession.

Such a device is not needed in the Whitehead torpedo, which makes its run at full speed, and is guided by its horizontal rudder. But with a torpedo intended to be used at varying speeds it is important that it should not be subject to the resistance of putting the horizontal rudder hard over.

The compressed air chamber is of Whitworth steel. Behind it comes the hydrostatic valve, the construction of which is a secret known to all the world. This valve, with its pendulum and servo-motor, acts on the horizontal rudder which keeps the torpedo submerged at any required depth. The next compartment contains the electric conductor. This is wound in the way indicated in Fig. 4, so that it runs out without friction and without twist. It is laid in circles from the center to the circumference, and is then reversed and laid the opposite way to the center. Fig. 5 is a full sized view of the cable with a part of the dielectric removed to show the strands. Fig. 6 is a similar full sized view of the cable controlling the naval torpedo. Behind the cable come the electrically governed spring motors, and then again the tower spherical engine, manufactured by Messrs. Heenan & Froude, of Birmingham, who have also constructed the torpedo. There are two propellers, right and left handed, in the usual way.

Figs. 7 to 9 show the electrically controlled spring motors; Figs. 10 to 12 show the air valve; Figs. 13 and 14 the cable clutches; Figs. 15 and 16 the cable guide; and Fig. 17 details of the float; Figs. 18, 19, and 20 show the cage in which the torpedo is held; and Fig. 21 illustrates the complete arrangement. The cage has



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four arms which completely encircle the body of the weapon. One arm of each set is fixed, while the other is pivoted and can be locked by a catch when the torpedo is in position. This catch is controlled by an electro-magnet connected by an insulated conductor to shore.

Each spring motor is connected with a small magneto motor which can be turned by the current sent along its particular conductor. At the end of the dynamo shaft is a pulley, E, around which there are wound two cords. One of these works a clutch lever, operating two half clutches, G, on the spring motor shaft, and putting one or other of them into engagement with the corresponding spring motors, H or J. The other cord works a pair of pawls, which engage with ratchet wheels on the shaft and limit its motion. Suppose a torpedo (Fig. 2) has been discharged from the shore either from a submarine cage, as in Fig. 21, or by being put directly into the water, and is proceeding at a comparatively slow rate; it is then desired to make it veer away to the right to bring it fairly in line with the enemy. An electric contact is made with a key on the proper conductor, and the dynamo, D (Fig. 8), is set in rotation.

This winds the end of the lever, F, over to the left, putting the clutch, G, into engagement with the spring motor, J. At the same time the second cord draws out the pawl, K, and puts in the pawl, L. As there is only one tooth on the ratchet wheel, the spring motor gives half a revolution, rotating the shaft and putting over the rudder. Directly the current is shut off, a spring pushes back K and releases L, so that M makes one complete revolution. If this does not bring the rudder round sufficiently again, the electric current is put on and a similar action takes place, and so on.

A reverse current by similarly operating the motor, H, brings the rudder in the opposite direction, and thus is the torpedo steered at any required angle, be it much or little.

At the desire of two foreign experts, two modifications of this mechanism have been made, by an alteration in the clutch, G, in the one case and a modification of the ratchet wheel in the other.

We will now suppose that all is ready for the final rush, and it is now necessary to open the air valve full to put the engines at full speed, and to cease dragging on the cable. The motor shown in the rear position in Fig. 7 is now operated by its cable. In construction this motor is identical with that shown in Figs. 8 and 9, and two cords are led from it to the spindle of the air valve (Figs. 10 to 12). Upon this spindle is a screwed sleeve working in a nut (not shown), and when the nut is turned the valve is opened or closed. In its closed position the valve is at the right-hand end of the valve chest; the first application of the current to the motor moves it slightly to the left, and allows the air to gain access to the distributing valve, N, of the engines and to set the latter in action. A reversal of the current temporarily applied opens the valve still further, and so on until it is full open, the entire action only lasting a second or two. Similarly by timing the application of the current, the valve can be more or less closed as desired.

At the moment the valve is opened full the cable must be released. To this end a cord is connected from the valve spindle to the tong clutches shown in Fig. 13. This cord is not rigid, but has a spring inserted in it. Any opening of the valve less than the full opening only requires such a motion of the rod as will stretch this spring. But with the full opening the tension exceeds the resistance of the springs, P P, and the toggle joint is drawn back, releasing the grip on the cable at Q. Should the valve be closed again. the grip will be renewed, since the toggle joint, R, does not go past the center. Thus the torpedo can make its run at full speed, and unencumbered. If it strike the enemy, it will explode by percussion. But should it be caught in a net or otherwise obstructed, the operator must explode it. For this purpose he makes use of his third conductor and motor. The latter is immediately behind the one shown upright in Fig. 7, and is similar to it. Its office is exceedingly simple; it is connected by a rod to a fuse in the forward compartment, and ignites it with an apparatus like the lock of a pistol. If a reverse current be sent, the motor overcomes the hydrostatic valve, and brings the torpedo to the surface, if it is in motion.

As we have already stated, the large torpedo may act with or without a float. Without a float it is simply an improved and controlled Whitehead, that can be brought to the surface when required, as might be necessary occasionally when at a very long distance, and otherwise controlled as described. With a float it is simply deprived of its buoyancy by using air at a higher pressure, but in every other respect is unaltered. The float enables it to be seen at almost any distance and also to get under netting. Mr. Murphy has designed the locomotive float, shown in Fig. 3. It has not yet, we believe, been constructed. It is, however, a small torpedo carrier, intended to travel just below the surface. It is connected to the main torpedo by a line, and is towed by the latter. This line is passed over some small pulleys, as illustrated in Fig. 17, and when it is drawn it pulls in the wings, opens the air cock, and gives the engine sufficient power to prevent the drag on the main torpedo.

The small torpedo (Fig. 1) can only be steered; it cannot have its speed controlled, since it has only one electric conductor, weighing slightly under ½ oz. per yard, and only one spring motor. The hydrostatic valve and heavy pendulum used in the Whitehead are dispensed with, as is the inlet of water to work the hydrostatic valve, and in place of them there is employed the float shown in the dorsal fin, which through a dashpot and a servo-motor operates a side fin, and so keeps the torpedo in a straight course about 2 ft. under water. This fin, by keeping the torpedo below the surface, also protects it from the missiles of the vessel attacked, and as the weight and utility of the float and dorsal fin would not be materially altered by being struck by ordinary bullets, this weapon is virtually bullet proof. If the torpedo turns either to dive or to shoot out of the water, the float, which should be just half submerged, causes the side fin to check it. This weapon makes its course at full speed, and does not need to have its buoyancy adjusted as it goes.

One of the purposes for which the large sized torpedo is specially applicable is the protection of merchantmen, at least those of them which are able to run away if they can only get a fair start. By means of one or two torpedoes they could keep their antagonist at a distance from which there would be little danger of being hit, until they could slip past, and show a clean pair of heels. This weapon can also be used on a man-of-war, but generally the smaller weapon (Fig. 1) would be used on board ship, on account of its greater simplicity, and the more perfect skill there available. The large torpedo with a float is adapted for shore defense. It has a range of two and a half miles, a very large store of compressed air, and is safe against hostile shot.

A practical trial, so far as any peace trial can be practical, is to be made of the Victoria torpedo in a week or two. It will be attended by experts from several governments, and some evidence of its capabilities will be given. If it performs one-fourth of what is claimed for it, it will be a great addition to naval armaments and coast defenses. Unfortunately, this country seldom makes it worth while for inventors to give it the exclusive use of their improvements, and, therefore, is no better off for all their exertions. Our only course at sea is to trust to "big battalions," since we have no weapons unknown to our possible invaders.—*Engineering.*

THE NEW STEAMER MAJESTIC.

THE Majestic and the Teutonic are sister ships of the same construction and dimensions. They belong to the White Star line, and are probably the finest steamships afloat. The two ships were ordered from Messrs. Harland & Wolff, of Belfast.

Messrs. Ismay, Imrie & Co. therefore gave the Belfast firm *carte blanche.* The builders do not guarantee any particular speed. They simply undertake to do their best. On the one hand came the order for the two best ships it was possible to build. On the other hand the promise that nothing that skill, talent, and experience, backed up by unlimited resources, could do to secure a satisfactory result would be left undone.

The ship has been carefully constructed for warfare in accordance with the views of Mr. White, chief director of naval construction. The engines are nearly below the water line, but coal armor can be carried to protect the small portion above the level. The rudder is so constructed that she can be made to steer with the lower half of it alone if the top were injured.

If we except some of the Italian ironclads, the Majestic and Teutonic are the largest ships in the world, the total displacement when fully loaded being not far from 16,000 tons. Gross tonnage 9,685 tons. She is 582 ft. long, 57 ft. 6 in. wide, and 39 ft. 4 in. deep, 4,244 tons register, can carry 855 fore cabin passengers, 164 second class, and 366 in saloon; or 1,385 in all. When fully loaded she has on board about 3,000 tons of coal and nearly 4,000 tons of cargo. In her engine and boiler rooms she carries twenty-five engineers. There are sixty firemen and forty-eight coal trimmers; electricians, ice machine men, etc., bring up the total engine room staff to 168. She carries a crew of about forty sailors, twenty-five cooks, and sixty stewards. Thus, when at sea she may have on board all told about 1,650 souls.

Concerning the fittings and decorations, almost the first idea conveyed by them is that they are the work of a thorough artist. In the Teutonic and Majestic the saloon and sleeping accommodations have been placed in the very middle of the ship, where there is the minimum of movement. The hurricane and promenade deck is 245 ft. long, with a clear width of 18 ft. on each side of the deck houses, free of all obstruction, the boats being placed on an awning deck on top of this again, which serves as a permanent shelter in place of the canvas now used for that purpose. On the promenade deck, besides the usual accommodation for the commander, there are good state rooms for passengers' use, having direct communication with the deck below.

Adjoining the main entrance is the library, containing bookcases filled with a careful selection of literature to satisfy the most exacting. It is paneled with light oak, the panels carrying a somewhat novel ornamentation produced by burning the design into a gilt ground, varied at short intervals by a tastefully carved panel with a figure after the best sixteenth century French and Italian work in low relief. The room is lighted at the sides by windows, covered by glass shutters of Italianesque design, all hand painted.

Passing down through the main entrance to the next, the upper deck, one finds in addition to the purser's quarters, deck state rooms for saloon passengers, furnished with baths, etc. Besides these rooms there are, on the same deck, further aft, the gentlemen's lavatory, the barber's shop, and the first class smoking room. The last is a somewhat special feature in these ships, an effort having been made to do away as far as practicable with the customary somewhat stiff seats of steamers' smoking rooms, and in their place to substitute comfortably upholstered couches. The walls of this room are covered with richly gilt embossed leather, the design being a careful reproduction of one of the best patterns of the old Flemish "cuir repoussé." Panels in the sides of the room are filled with oil paintings representing shipping from some of its most picturesque aspects; ships of war, old and new, dating from the gayly decorated Venetian Republic and the other great naval powers of the Mediterranean in the middle ages. Other spaces are filled with shallow niches, each holding a figure in high relief, carved in pearwood after Donatello. The ceiling follows an old English plaster pattern in quaint variously shaped panels, with modeled rosettes at intervals. The deck here and in the companion way, etc., is covered with tessellated tiles made of vulcanized rubber by the Silvertown company. Shutters of ornamental glass are arranged to obscure the windows of the room at night. Retracing one's steps to the main staircase, and passing down to the next, the main deck, the principal saloon is entered, which, apart from its size, presents many novelties both in design and construction. In general the decoration is of the Renaissance period, and the prevailing tones ivory and gold. The walls are penciled out by a shallow moulded framework, highly enameled and slightly relieved with gold, while the panels in this framework are executed in a glyptic material, in which tritons, nymphs, and other oceanic symbols appear.

The figures in relief have an ivory-like surface and tint, and the groundwork of the panels is of gold. The ports are lined with repoussé brasswork of the same Renaissance character as the walls, and are fitted with stained glass blinds emblazoned with the arms of the principal states and cities of America, Canada, and Europe, behind which are placed electric lights, so that the brightness of the design will be apparent by night or day. The ceiling, like the walls, is in ivory and gold richly ornamented, the electric light being introduced into the ornamentation of the ceiling in place of the usual hanging lamp.

Forward of the saloon and also immediately below it are the first-class state rooms, a large proportion of these being two-berth rooms only, and so arranged that there will not be both upper and lower berth in the same room. Numerous rooms of large size for families are provided, as well as rooms suitable for a single passenger only.

In every state room an effort has been made to give an attractive and homelike appearance to its furniture by means of easy chairs, chests of drawers, hanging cupboards, etc., and as is now almost universally the case, the electric light in each room is under the control of the occupant, and available at will. Ample bath and lavatory accommodation of the most modern description is provided closely adjoining each section of the saloon quarters; also a good baggage room easily accessible for articles wanted on the voyage.

Nothing is said here, it will be noticed, concerning the second class accommodation. That is, however, equal to the first class accommodation of not a few very large steamers making long voyages. The decorations and upholstery are not so expensive as in the saloon, but as far as space and comfort are concerned the second class leaves nothing to be desired. The emigrants' quarters are in like manner above the standard hitherto maintained in the best Atlantic steamers.

The hull of the Teutonic has been constructed on a system which, if not absolutely new, has not before, so far as we are aware, been adopted in large Atlantic steamers. In the normal method of building, the vertical joints of the skin plating are made up with single butt straps inside, double, single, or treble riveted, according to circumstances. The rivets are in single shear, as it is well known that there is a tendency to open manifested by the joints.

Messrs. Harland & Wolff unite the ends of the plates by simple lap joints, the most forward plate always lapping over the plate next sternward, so as to prevent increase of resistance. The joints are treble, quadruple, and in some plates quintuple riveted. The skin plates were made by the Steel Company of Scotland—most of the beams being by Dorman, Long & Co.—and are of unusual dimensions, being 24 ft. long and 3 ft. wide.

She is fitted with twin screws; and the whole of the machinery, engines, boilers, and coal for working either screw independent completely from its neighbor by a fore and aft bulkhead, which extends from the after end of the engine room to the forward end of the foremost coal bunker, and, in fact, intersects the six largest of the twelve water tight compartments made by the eleven ordinary transverse bulkheads. This fore and aft bulkhead is pierced by only one locked door, the key of which is held by the chief engineer. The doors between the engine rooms and the stoke holes are in every instance duplicated, and the duplicate door is in every case under the control of the captain on deck. When liberated they close by their own weight, but they are fitted with glycerine cataracts to ease their descent. In the event of water flowing into the ship, the doors will close automatically. As the water rises in the bilge it will buoy up a hollow piston attached to a rod. This rod on being pushed up about one foot removes the catch that holds the door.

The engines are triple expansion, with three cylinders of 43 in., 68 in., and 110 in. in diameter, and they have been constructed to develop 17,000 horse power. The pistons have a 5 ft. stroke, and the machinery, in accordance with Admiralty requirements, has all been placed below the water line. The boilers are twelve in number. Some are 12 ft. and some 12 ft. 6 in. in diameter and 17 feet long, with six furnaces in each, and a grate area of 1,163 ft. The furnaces are fed with forced air to a moderate extent above the fuel and under the grate, and the boilers are designed to work up to 180 lb. The initial pressure in the intermediate cylinder is 80 lb. and in the low about 16 lb., with a vacuum of 27 in.

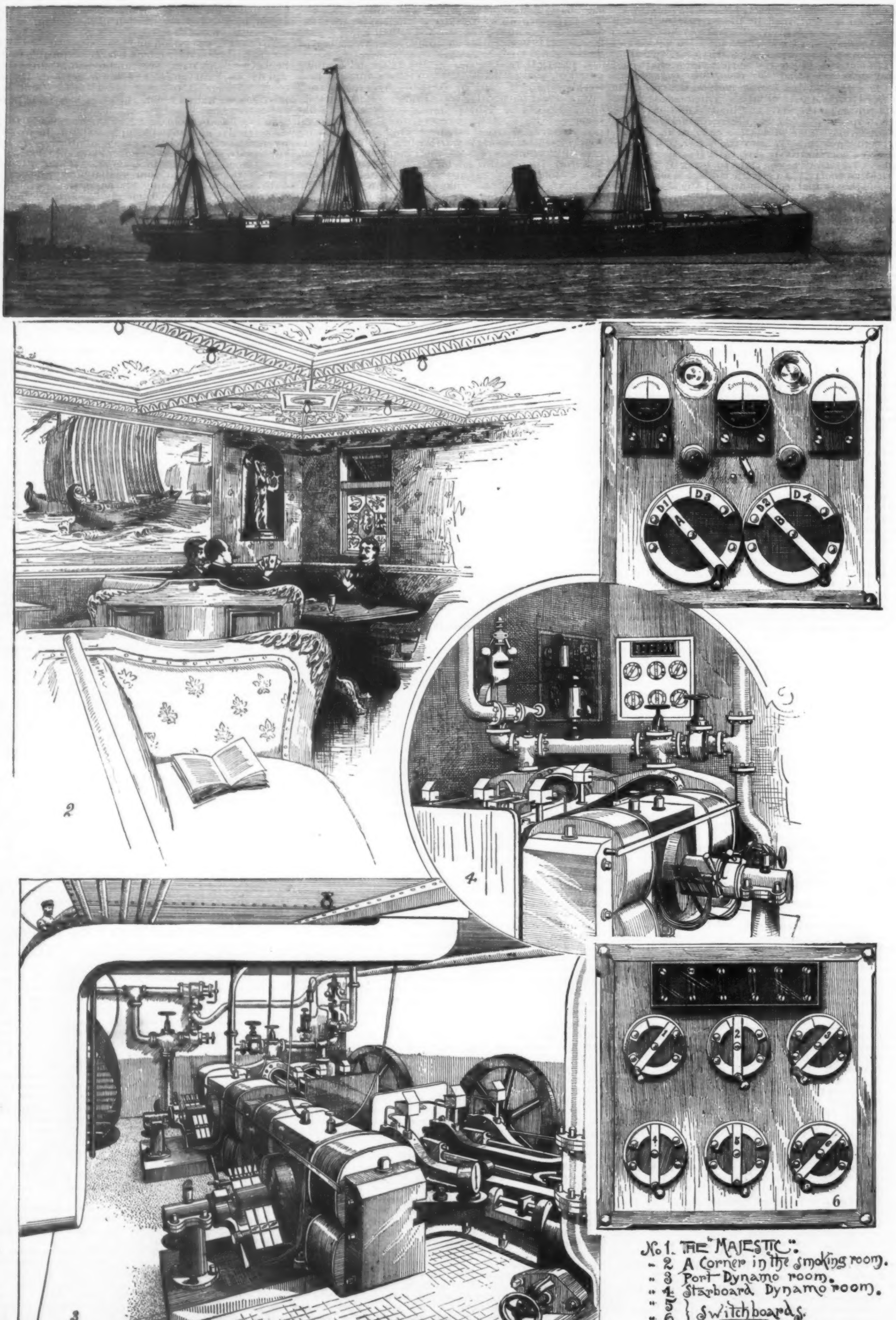
The propellers, which are 21 ft. 6 in. diameter, with a pitch of 28 ft. 6 in. and a superficial area of 128 ft., form a subject of special interest in this ship on account of the unusual manner in which they are placed. They overlap each other to the extent of 5 ft. 6 in., or, in other words, they each extend over the center line 2 ft. 9 in. The centers of their axles are 16 ft. apart, and the port side propeller is 6 ft. forward of the starbord, measuring from boss to boss. The port propeller is a left handed screw and the starboard a right handed; thus both work away from the ship; and the port propeller working in the loose water of the after screw makes two revolutions a minute more than its twin. The propeller shafts are 199 ft. and 205 ft. long respectively, and are entirely incased to the boss of the screw. The hull is very much cut away under the stern, and a large space has been cut in the frames to admit of the massive casting that carries the screw shafts. The stern post is connected with the rudder post by a bar on the line of the keel in the ordinary way, the scheme of allowing the rudder to be suspended without support below having been abandoned as dangerous.

She has a cutter stem, and, relying wholly on her two sets of engines, the masts are little more than three bare poles without yards.

For the foregoing particulars we are indebted to the London *Engineer.* For the following relating to the electric machinery and for our engravings we are indebted to the *Electrical World:*

Far down in the after part of the engine room, with three grated iron decks above, are located the two dynamo rooms where the power for lighting is supplied. These dynamo rooms are almost exact duplicates of each other, one of them being on each side of the great longitudinal bulkhead. They are entirely independent of each other, so that in case of accidental flooding of the engine room or the like, facilities for lighting would still be available. In each of the two dynamo rooms are placed a pair of compound wound dynamos, each being driven by an independent engine.

The dynamos are of the well known Crompton type, with a ring armature of large diameter and many sections. Each is capable of producing 240 amperes at 100 volts potential when driven at its usual speed of 192 revolutions per minute. As in all slow-speed machines, the field magnets are very massive. Square wire is freely used in the winding, a feature unusual in machines designed on this side of the Atlantic. Each of these dynamos is coupled direct to a Tangye parallel compound engine of 7 inch stroke. The high and low pressure cylinders are respectively 8 and 16 in. in diameter. Steam at 180 lb. pressure is obtained



THE NEW STEAMER MAJESTIC.

from the main boilers. These engines have cranks set 90 degrees apart, and run with great smoothness and regularity. Fig. 3 of our cut shows a view of the port dynamo room, exhibiting couplings of engines and dynamos, and the arrangement is the same on the starboard side. Fig. 4 shows the latter and gives a clear idea of the details. The switchboards, Figs. 5 and 6, are placed as shown in the starboard dynamo room and in the corresponding corner of the port dynamo room. The connections are so made that the entire load can be thrown on any one dynamo or any combination of dynamos, so that it would hardly be possible to cripple the lighting plant entirely. From these dynamo rooms the main cables reach out over the ship, supplying the lamps. The primary lead is a cable of 19 No. 14 B. W. G. wires, while the branch leads diminish in size until the single lamp wiring is done with a No. 18 B. W. G. wire. Instead of having the usual parallel system used on lamps, the ship is used as a return circuit, as is not infrequent in ship lighting. The Majestic is wired for about 1,200 16 c. p. incandescent lamps, besides others of 50 c. p. for side and masthead lights. All the wiring is in mouldings. Most of the lamps have ground bulbs, although some are of clear glass, and others of clear glass and ground globes. About 1,000 lamps were lighted on the trip over, the load not being thrown on all the dynamos at any one time, but shifted from pair to pair to distribute the work. No electroliers are in use, all the lights being dropped just below the moulding, and the carrying wires are being plentifully distributed over the ship. The saloon and dining room lights are specially numerous. A corner of the beautiful smoking room is shown in Fig. 2, with the lights on the ceiling at the sides. The soft light that sifts through the ground glass bulbs produces a beautiful effect on the interior decorations. There is one noticeable difference between incandescent lighting here and that used in American plants. Few of the lamps are provided with key sockets, the English plan being to control the lamps by a group of switches instead. There is an elaborate system of cut-outs, however, special care being taken in this respect.

Besides lighting the ship, the dynamos furnish current for a small motor which is used in the barber shop. Other motors might advantageously be used in various positions on the ship, but our English cousins do not seem to have been thoroughly broken into the idea of distributing power freely by this means.

An interesting question might be raised as to whether the wide distribution of electric currents over a ship that is necessary for extensive lighting might not produce some effect on the ship's compass. By experience it is shown that there is no trouble to be experienced on this score, the action of the currents being only local and by no means far-reaching enough to disturb the compass needles, which, for other reasons, are located far from any such disturbing cause.

The lighting of the Majestic is very complete, and the machinery is reported by the electrician as working with great smoothness, having given almost no trouble on the run over. The arrangement of the lights is not striking nor ornamental, but is very effective. The visitor sees nothing but the little ground glass bulbs scattered freely at every point where light is necessary, all the wire being invisible; and it is only when the current is turned on, and the whole great steamship glows with light, that he realizes the care that has been spent in providing means for so perfectly accomplishing the work.

THE LONDON ELECTRIC UNDERGROUND RAILWAY.

The City and Southwark Subway, London, is now so rapidly approaching completion that some attention may usefully be directed to it, as a very important means of communication between the south and southwest of London and the City at King William street. In 1884 the subway company was incorporated and empowered by act of Parliament to construct a double subway line from King William street to the Elephant and Castle, thus providing access to the City not possible by the tramways, which must necessarily stop some distance below the crowded approaches to London Bridge. By a further act in 1887 the subway company was empowered to carry the line to Clapham road and Stockwell. It was proposed when the line was first set out that the trains upon it should be worked by cable haulage, but since that time it has been determined to work it by electric locomotives of about 100 horse power each, the parallel system being adopted and the construction of the machinery for the propulsion placed in the hands of Messrs. Mather & Platt. The engineer of the line is Mr. J. H. Greathead, M. Inst. C. E., Sir John Fowler the consulting engineer.

Some remarkably rapid tunneling work has been done in the execution of the work, the system adopted being due to Mr. Greathead, who has for many years paid special attention to the construction of tunnels by systems similar to that here used; that, for instance, of the small tunnel at the Tower upon which he was engaged, and which is used as a footway. The mode of construction adopted in the City and Southwark Subway is in some respects quite new, and it has proved to be cheap, rapid and effective, and so much so that simply as a system of tunnel excavation through the London clay it has advantages which will be referred to later on.

The route of the subway, and the position of the stations, are shown on the accompanying map. The City station, near the Monument in King William street, is very wisely placed in a main thoroughfare. This is an important point, for with the great omnibus competition, passengers are tempted, even though they know loss of time will result, to jump into a passing omnibus rather than walk down a side street to gain the more rapid transit of a railway. The next station is in Great Dover street at the junction of Borough High street and Newington Causeway. The next is near the Elephant and Castle at the west end of New Kent road. From this point the subway runs under the Kennington Park road and the Clapham road, with stations at New street opposite the White Hart, another close to Kennington Oval and near the top of Camberwell New road, and another at Binfield road, opposite the Swan at Clapham.

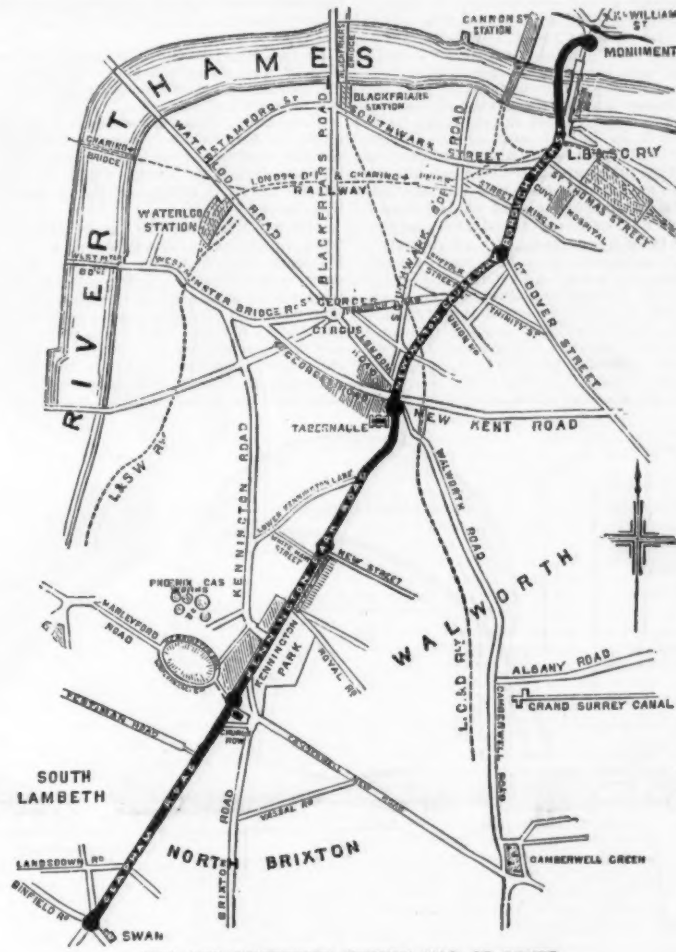
At each station powerful hydraulic lifts will be provided in addition to the stairways, for the purpose of giving easy and speedy access between the street and the platform levels. And in order to avoid double establishment on opposite sides of the road at each station, the "up" and "down" tunnels will there be placed at different levels, so that passengers may pass readily from the lifts or stairs on one side of the road to either platform. The steepest gradient against the load will be about 1 in 30, namely, where the up line runs from near the river to Monument station, but the line throughout the greater part of its length will be practically level.

The tunnel has now been completed, and work is rapidly progressing at the stations, and the whole of this has been done without the slightest interference with any business or traffic along any of the thoroughfares under which the subway has been made. Even at the City end, and in tunneling under the river Thames, the only evidence of the progress of the work was the temporary stage and shaft near the north shore, but not so near as to interfere with the wharfage.

It would be more accurate to speak of the subways, for the up and the down lines are carried in two distinct tunnels. These not only cost less in excavation and lining than one, but the two may be placed in any desired positions relatively to each other as may be required to suit local circumstances. They may be placed one above the other, at greater or less distances apart, and at any necessary relative levels. The advantages of this will be seen hereafter. At the Monument station they are side by side and on the same level. From this point, that which will contain the "down" line, as it will be called, falls more rapidly than the "up" line subway, in order that when Swan lane is reached, close to the river, the "down" subway may be immediately under the "up" subway line, because, except in this position, they could not be constructed without encroaching upon private property or rights.

In this position, as shown in Fig. 2, they pass under the northern foreshore of the river Thames. But before the southern shore is reached they are again side by side—as required by a clause in the act—and at each intermediate station, as already described, they are at different levels. The diagram—Fig. 2—shows the tunnels as they have been constructed under the river. A little south of the center of the river there is, at the lowest part of the "up" line, a cross heading, connecting the two subways, so that both may be drained from the one sump.

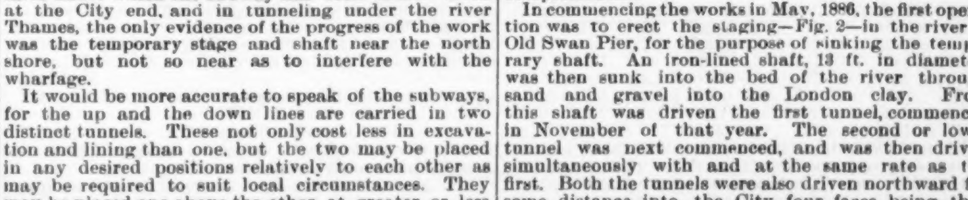
Each of the tunnels is 10 ft. 6 in. in diameter within the flanges, and is formed of rings of cast iron segments bolted together through internal flanges, as shown in Fig. 3. The rings are 1 ft. 7 in. long. All the flanges are 3⅛ in. deep and 1¼ in. thick. In the longitudinal joints thin strips of pine are inserted between the flat surfaces of the iron, and subsequently pointed with cement. The circular joints are made by tarred rope and cement. The segments are not tooled in any way, but are used as they come from the foundry. Care is taken that they are correct in curvature before leaving the foundry and no trouble has been experienced in putting the segments together, and none have broken in being put in. The subways are generally in the London clay, but there are short lengths where gravel and sand were encountered, badly charged with water in the first case about fifty yards from the river, on the north side. The system of construction made this an easy task. This work was done by the aid of the pumping machinery usually resorted to. In constructing the subway, however, the method of working adopted excluded the water altogether, the men working under compressed air.



CITY AND SOUTHWARK SUBWAY—MAP OF ROUTE.

In commencing the works in May, 1886, the first operation was to erect the staging—Fig. 2—in the river at Old Swan Pier, for the purpose of sinking the temporary shaft. An iron-lined shaft, 13 ft. in diameter, was then sunk into the bed of the river through sand and gravel into the London clay. From this shaft was driven the first tunnel, commenced in November of that year. The second or lower tunnel was next commenced, and was then driven simultaneously with and at the same rate as the first. Both the tunnels were also driven northward for some distance into the City, four faces being thus worked from one shaft. The second tunnel was driven immediately under and within 4 ft. 6 in. of the upper tunnel. It will be observed that the first or upper tunnel has a dip under the river, and that the second or lower tunnel rises continuously from the shaft. The cross heading already referred to, joining the two tunnels at the lowest point of the first, provides for draining that tunnel to the sump, which will be permanent. From this any accumulation of water will be discharged automatically by one of Greathead's injector hydrants, deriving its supply of high-pressure water from a hydraulic main, which will be placed throughout the length of one of the subways for providing the power for working the hydraulic lifts at the stations, and for any other purpose.

Fig. 2



The mode of constructing the tunnels and lining them may be described by reference to Fig. 4. An excavation at the bottom of the shaft having been made, a steel cylinder, 11 ft. 6 in. in diameter, and 6 ft. 6 in. in length, was got into position, and the segments of several rings of the permanent iron tunnel jointed and bolted up. Within the forward end of the steel about 6 in. from the front end, is fixed a very stout cast iron ring, A, to which is fixed a strong plate forming the outer part of a shield, and having an aperture of about 6 ft. in height and 4 ft. 6 in. in breadth, through which the miners and the spoil can pass. This aperture is made to receive a number of strong planks,

which can rapidly be put in place in case of any sign of irruption of water. Within the inside of the heavy cast iron ring, A, are fitted six hydraulic press cylinders. The heads of the rams of these hydraulic presses abut against the last ring of the completed tunnel. In front of the shield is provided a cast iron ring, fitted with steel cutters or tines, as shown in Fig. 4, for cutting into the clay or other earth to be excavated. In addition to these it was found that hard wood wedges about 2 ft. in length and about eight in number, inserted by the miners at their discretion as to position and angle greatly facilitated the excavation. This is roughly shown in the diagram, Fig. 5, which shows part of the steel cylinder, press ring, and shield, but the wood wedges, B, should be shown in the position given in Fig. 5A, which shows the position of the steel cutters, S, and the cast iron ring in front of the shield bulkhead. A ring of the tunnel having been inserted and bolted up, within and under cover of the steel cylinder, the miners cut away the clay in front of the shield and throw it back through the opening into the tunnel. Enough clay is cut away all round the circumference to permit the shield to be forced on the length of one ring of the cast iron lining: but in the central part an advance heading is made, about 5 ft. in height and about 3 ft. in width. In shaky or watery ground this would only be made from one or two to perhaps three ft. ahead of the shield; but in the hard London clay it could be made any necessary or useful distance ahead of the shield, but more than about 8 ft. ordinarily secures no advantage. The material then being removed immediately round the shield, the miners push in the wood wedges between the clay not cut away and the face of the shield. The hydraulic presses are then set to work, and the wedges and steel cylinder are driven forward as in Fig. 5A, the clay being broken inward in lumps as indicated, some falling into the advance central cutting and the remainder being so broken that, as seen in the sketch, it is easily brought down with the picks and the way cleared for another advance of the shield and the addition of another ring of lining. The spoil is carried away from the inside of the shield in small iron trucks, hauled by ponies to the nearest shaft. The steel shield cylinder, it will have been observed, clears out a circle a little larger than the outside of the cast iron tunnel lining. A small annular space is thus left outside of the cast iron rings. This space is filled in with blue lias lime grouting forced into the space under pressure of compressed air at a pressure of about 30 lb. per square inch. The lime is mixed with water in the cylindrical vessel shown at Fig. 6. The lid is then closed and the compressed air, supplied by a compressor at the nearest shaft, is admitted through the upper valve, V. The lower valve V¹ is then opened, and grouting is forced through a short length of strong hose fitted with a nozzle, which is inserted in holes provided in each of the segments of the cast iron lining. The grout is first forced through the holes in the lower segments until it appears at the holes in the higher segments. The lower holes are then plugged and the nozzle inserted into the next hole above, and so on, until the grout appears at the top hole. The nozzle is then inserted in the top hole and the grout forced in until the whole annular space is filled with grout under the full pressure. The paddles in the grout-mixing vessel are kept in motion to prevent setting. The iron lining is thus not only surrounded by a coating of lime cement, but the joints of the segments are made quite tight by it. At the stations, considerable lengths of the lining have been taken out in the progress of enlargement to construct the platform spaces, and in these cases it has been found that the hard clay was cut away by the steel cylinder, leaving a smooth bore, and the annular space was everywhere perfectly filled with the lime coating, so that the lining was most perfectly embedded, removing all chance of settlement or infiltration of water. The tunnels have thus been driven without a single case of cracks to buildings throughout the long length from the south of the river to Clapham road. Some householders hearing that a tunnel had been constructed, discovered cracks in their buildings and hoped for compensation, but Mr. Greathead, unfortunately for them, had made full use of the photographic lens, and had possessed himself of photographs of every wall and building in the least likely to be within the limits of the tunneling effects. These awkward pictorial evidences of old cracks provided very rapid means of settling disputes on the subject.

The success and rapidity of this method of tunneling were so great last year that three miles of the tunnel were driven—two and one-fifth miles in the second half—in the heart of London, without one temporary shaft or opening in the streets, the work proceeding simultaneously, on an average, at six faces. It has been mentioned that the tunnel was driven and lined at the sites of the stations, as elsewhere. It was found quicker to proceed in this way, making no break in tunnel work, than to excavate at the stations to the full size at first, and make so many more starts of the tunneling arrangements.

It is remarkable that this system of tunneling has not been more largely adopted in preference to the ordinary methods of procedure, and the use of brick lining.

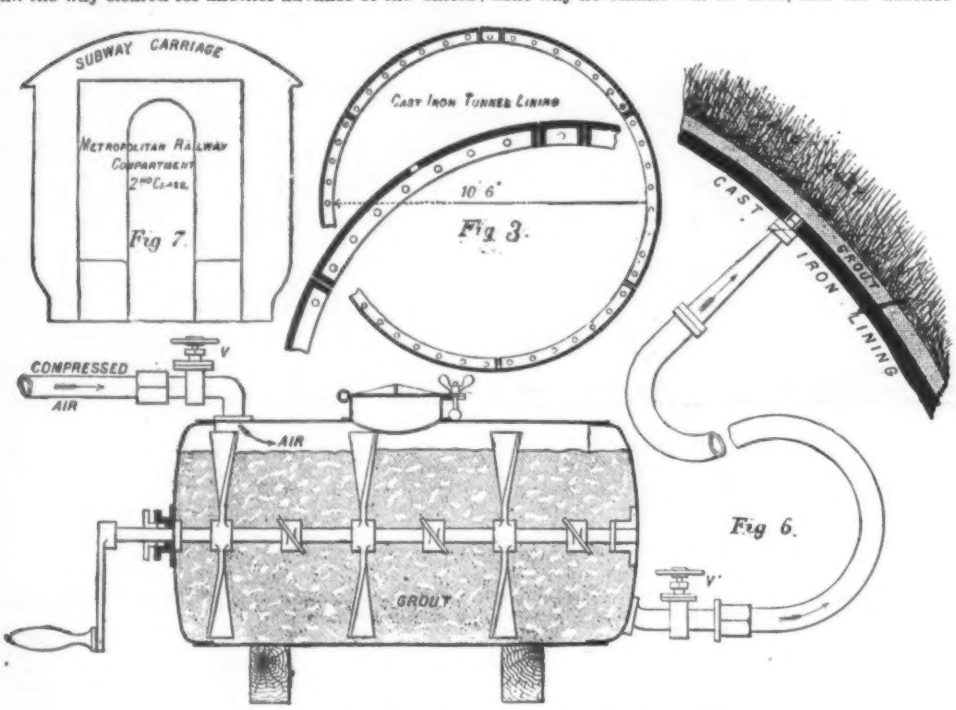
In the construction of the little Tower subway in 1868-69, under the late Peter Barlow, it was adopted by Mr. Greathead, but the hydraulic and the pneumatic power were not employed.

Since then, some unsuccessful attempts have been made in America to make brick-lined tunnels with shields, somewhat similar to that used at the Tower, but the cast iron lining, which for moderate sizes of tunnel at least offers so many advantages, has not been used.*

The carriages are to be of the longitudinal type, with platforms and entrances at the end, similar to Pullman and ordinary tramway cars. They will be very commodious, giving greater height and width than the second and third class carriages in use on the Metropolitan Railway—see Fig. 7—and to each passenger about 30 cubic feet of capacity as compared with the 30 required by the Board of Trade regulation for railways. The stations are to be lighted by electricity, with gas in reserve. In connection with the permanent way no ballast will be used, and the absence of heavy locomotives will enable a smooth line to be maintained at comparatively small expense.

It is intended to run light frequent trains at about the same speed as on the existing underground railways, but passengers will not be troubled with, or the purchase of, tickets. In the first instance, at all events, it is intended to adopt a uniform fare, and passengers will simply pay at a self-registering turnstile, and thus all booking office expenses and troubles will be avoided.

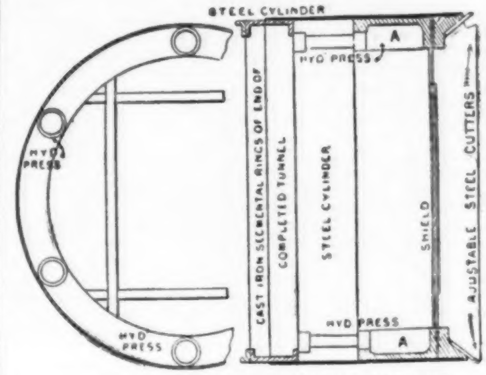
The adoption of electric haulage, in place of the cable haulage at first intended, will make little difference in the general arrangements, but the tunnels will, of course, be freed of the pulleys, traveling ropes, and other necessaries to that system. The current generating station will be very near the Swan, and nearly opposite the Clapham road station. The electromotives will weigh about twelve tons each, and will be of about 100 horse power each. The current will be taken from an overhead conductor on the parallel system. The contractors for the work are Messrs. Walter Scott & Co., and Sir W. G. Armstrong, Mitchell & Co. are constructing the hydraulic lifts for the stations.—*The Engineer, London.*



GREATHEAD'S GROUTING DEVICE FOR TUNNELS.

*[Our cotemporary has been misinformed in regard to the history of the hydraulic shield and its uses on this side of the Atlantic.

It is the invention of Mr. Alfred E. Beach, of the Scientific American, and was designed by him in 1865, and tried in 1868 (patented 1869) for the purpose of excavating under the streets of New York, with a view to an underground railway. At that early period the need of rapid city transit for passengers was strongly felt, but there was great opposition on the part of property owners along the line of the proposed railway, through fear that the buildings would be injured if a tunnel were carried on a lower level than the foundations; added to which would be serious loss of business by the closing and tearing up of the streets during the construction of the work. Mr. Beach determined to show the fallacy of both of these objections by excavating a short piece of tunnel under the most crowded part of Broadway, at a lower depth than the adjacent buildings, and without interrupting business or traffic. He accordingly constructed the hydraulic shield or underground boring machine, which he set to work, and with it constructed a tunnel extending under Broadway from Warren Street to Park Place, large enough to receive a small street railway car, the length of the tunnel being between three hundred and four hundred feet. This tunnel was 9 ft. 4 in. in exterior diameter. It was started at the head of Warren Street, from which it turned underground on a radius of about 50 ft. into Broadway. The curved portion of the tunnel was walled with cast iron plates, put up in segments and united by means of screw bolts; the straight portion was walled with brick masonry. The object of the shield was to protect the workmen while excavating the earth and building the tunnel.



TRANSVERSE & LONGITUDINAL SECTIONS OF TUNNEL END AND SHIELD

Fig 4

The shield consisted of a strong cylinder somewhat resembling a huge barrel with both heads removed. The front end of the cylinder was sharpened, so as to have a cutting edge to enter the earth. The rear end of the cylinder, for a length of two feet or so, was made quite thin, and called the hood. Arranged around the main walls of the cylinder and longitudinal therewith were a series of hydraulic rams, all operated from a common pump, each ram having cocks, whereby it could be cut off from the pump whenever desired.

Within the shield were vertical and horizontal braces and shelves. When at work, the iron plates or the masonry of which the tunnel is composed are first built up within the thin hood of the shield, the hydraulic rams are then made to press against the end of the tunnel plates or masonry, which has the effect to push the shield ahead into the earth for a distance equal to the length of the pistons of the rams, say two feet, or not quite the length of the hood, and as the shield advances, men employed in the front of the shield

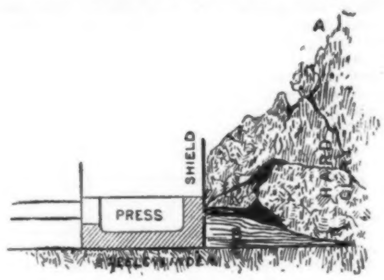


Fig. 5.

dig out and carry back the earth through the shield. By the advance of the shield, the hood, within which the iron or masonry tunnel is built, is drawn partly off from and ahead of the constructed tunnel, thus leaving the hood empty. The pistons of the hydraulic rams are then shoved back into their cylinders, and a new section of tunnel is built up within the hood as before described. The shield is then pushed ahead, and so on. The extreme end of the tunnel is always within and covered and protected by the hood. In this manner the earth is rapidly excavated or bored out, and the tunnel built, without disturbing the surface of the ground.

The floor of the Broadway tunnel above mentioned was 21½ feet below the pavement. It was carried under sewers and beneath the Croton water mains. The work was executed while the street was thronged with omnibuses and heavy teams, and few persons, except those directly interested, had any knowledge that a tunnel was in progress until after it was completed.

Fig. 5A.

pleted. It was then opened to the public, and many thousands of people enjoyed the privilege of riding in the car, which was worked back and forth in the tunnel by the pneumatic or air pressure system.

By means of the system of hydraulic rams capable of either combined or separate action, Mr. Beach was enabled to govern the direction of his tunneling shield with the utmost precision, making it to ascend or descend in the earth, according to the grade required, or travel on a curve of any desired radius. The first ma-

chine attracted much attention on the part of engineers. It was illustrated and described in the Scientific American of March 5, 1870, also in the *Manufacturer and Builder* of the following year, and in various other publications.

By comparing the engraving given in the Scientific American of 1870 and that shown in Fig. 4 of *The Engineer*, it will be seen that the two constructions have a close resemblance; they are, in fact, substantially similar.

Since the construction of the Broadway tunnel, the Beach hydraulic shield has been employed on a number of important engineering works, with much success, and it is now generally recognized as an important adjunct in the execution of various classes of underground tunnels. At Buffalo it was used to carry a large sewer under a main street and under a canal. At Chicago it was used in the construction of one of the lake tunnels. In addition to the two tunnels for the London Electric Underground Railway, the great railway tunnel lately completed under the St. Clair River, between Port Huron, Michigan, and Sarnia, in Canada, was excavated by means of the Beach hydraulic shields, in the most rapid and successful manner. Two shields were employed, one on each side of the river, and the entire tunnel, 6,050 ft. long, was executed and walled with iron plates in about one year's time. The shields here used were 27 ft. 7 in. in diameter, and 16 ft. long. Each shield weighed 80 tons. For illustrations and descriptions of these shields see Scientific American Supplement, No. 764.

The Beach hydraulic shield is also now in use in the construction of the railway tunnel now in progress under the Hudson River between New York and Jersey City. The shields here used are 19 ft. 11 in. in diameter and 10 ft. in length. Two great tunnels are being constructed, one of which is now completed for about half the distance across the river.]

MEETING OF THE BRITISH ASSOCIATION, 1890.

Leeds was the chosen place this year for the assembly of the British Association, which took place Sept. 2.

The following was

The Inaugural Address, by Sir Frederick Augustus Abel, C.B., D.C.L. (Oxon.), D.Sc. (Cant.), F.R.S., P.P.C.S., Hon. M. Inst. C.E., President.

Many who had the pleasure of listening last year at Newcastle to the interesting and instructive address of the president to whom I am a most unworthy successor, could not fail, both by the chief subject of his discourse, and by the circumstance of the official position which he occupies with so much benefit to science and the public, to have their thoughts directed to the illustrious naturalist whose philosophical address delighted the members of the Association and the people of Leeds thirty-two years ago.

More than one half the period of existence of this Association has passed since Richard Owen presided over its meeting in this town. Alas! what gaps have been created in the ranks of those who then were prominent for activity in advancing its work: The then general secretary, Sir Edward Sabine; the all-popular assistant general secretary, John Phillips; the treasurer, John Taylor, now live with us only through their works and the enduring esteem which they inspired.

But very few of those who held other prominent positions at that meeting have survived to see the Association reassemble in this town. Whewell, Herschel, Hopkins, the elder Brodie, Murchison, William Fairbairn, all presidents of sections in 1858, have long since been removed from among us. And the then president of section F, Edward Baines, a much honored and highly talented son of the "Franklin of Leeds," whom we had hoped to count among those vice-presidents representing the city on this occasion, has recently passed away in his ninetieth year, after a most honorable and useful career, during which he especially distinguished himself by his successful exertions in the advancement of the great educational movements of his time.

The illustrious president of our last meeting here, concerning whose health the gravest apprehensions were not long since entertained, is happily still preserved to us; still intellectually bright at the ripe age of eighty-six, and still, with the keen pleasure of his early life, following the progress of those branches of scientific research which have constituted the favorite occupations and the arena of many intellectual triumphs of a long career of ardent and successful devotion to the advancement of science.

To not a few of those who have flocked to Leeds to attend the annual gathering of this Association, our present meeting place is doubtless known chiefly by its proud position as one of the most thriving manufacturing towns of the United Kingdom. Of ancient renown, especially in connection with one of the chief industries identified with Great Britain in years past. But this good town of Leeds, whose cloth market was described by Daniel Defoe, one hundred and sixty-odd years ago, as "a prodigy of its kind, and not to be equaled in the world," and whose present position in connection with divers of our great industries would have equally excited the enthusiasm of that graphic writer, is famous for other things than its prominent association with manufactures and commerce.

Not many of our great industrial centers can boast of so goodly an array, upon the scroll of their past history, of names of men eminent in the sciences, the arts and manufactures, in divinity and letters, and in heroic achievements, such as are identified with Leeds and its immediate vicinity: Thomas, Lord Fairfax, one of the most prominent heroes of the commonwealth; Smeaton, an intellectual giant among engineers; William Hirst and John Marshall, illustrious examples of the men who by their genius, energy, and perseverance placed Great Britain upon the pinnacle of industrial and commercial greatness which she so long occupied unassailed; Richard Bentley, the eminent classic and divine; John Nicholson, the Airedale poet; John Fowler and Peter Fairbairn, worthy followers in the footsteps of Smeaton; Isaac Milner, weaver and mathematician, afterward Senior Wrangler, Smith's Prizeman, Jacksonian Professor, President of Queen's College, Vice-Chancellor of Cambridge University, Dean of Carlisle, and a most illustrious fellow of the Royal Society; Thoresby, antiquarian and topographer; Benjamin Wilson, painter, and industrious contributor to the development of electrical science; William Hey, the eminent surgeon, and friend and counselor of Priestley; Sadler, political economist and philanthropist; the brothers Sheepshanks—Richard, the astronomer, and John, the accomplished patron of the arts, and munificent contributor to our national art treasures; Edward Baines, whose conspicuous talents and energy developed a small provincial journal into one of the most powerful public organs of the country; his talented sons, of whom not the least conspicuous and highly respected was the late Sir Edward Baines.

I might swell this voluminous list by reference to illustrious members of such families as that of Denison,

SIR FREDERICK AUGUSTUS ABEL, C.B., F.R.S., D.C.L., LL.D., PRESIDENT OF THE BRITISH ASSOCIATION.

of Beckett, of Lowther, but the men I have referred to fitly illustrate the remarkable array of worthies whose careers have shed luster upon the town in or near which they were born. Yet that illustration would be altogether incomplete if I failed to speak of one whose career and works alone would suffice to place Leeds in the foremost rank of those English towns which can claim as their own men whose course of life and whose achievements have secured their pre-eminence among our illustrious countrymen. Needless to say that I refer to Joseph Priestley, born within six miles of Leeds, whose name holds rank among the foremost of successful workers in science, who by brilliant powers of experimental investigation rapidly achieved a series of discoveries which helped largely to dispel the shroud of mystery surrounding the art of alchemy, and to lay the foundation of true chemical science. An ardent student of the classics, of eastern languages, and of divinity, a zealous exponent of theological doctrines which marked his career as divine and instructor, he early displayed conspicuous talent for the cultivation of experimental science, which he pursued with ardor under formidable difficulties. His acquaintance with Franklin probably developed the taste for the study of electric science which led him to labor successfully in this direction, and the publication, in 1767, of his valuable work on "The History and Present State of Electricity, with Original Experiments," secured for him a prominent position among the working fellows of the Royal Society. His connection with Mill Hill Chapel, in 1768, appears to have given rise

SIR DOUGLAS GALTON, K.C.B., GENERAL SECRETARY OF THE BRITISH ASSOCIATION.

accidentally to his first embracing the experimental pursuit of what formerly was termed pneumatic chemistry, the foundation of which had been laid by Cavendish's memorable contribution, in 1766, to the Philosophical Transactions, on carbonic acid and hydrogen. Priestley's first publication in pneumatic chemistry, on "Impregnating Water with Fixed Air" (carbonic acid) attracted great attention. It was at once translated into French, and the College of Physicians addressed the lords of the treasury thereon, pointing out the advantages which might result from the employment, by men at sea, of water impregnated with carbonic acid gas, as a protective against, or cure for, scurvy.

Six years later Priestley investigated the chemical effects produced on the air by the burning of candles and the respiration of animals, and, having demonstrated that it was thereby diminished in volume and deteriorated, he showed that living plants possessed the power of rendering air, which had been thus deteriorated, once more capable of supporting the combustion of a candle. At about this time Priestley received very advantageous proposals to accompany Captain Cook upon his second expedition to the South Seas. But when about to prepare for his departure he learned from Sir Joseph Banks that objections against his appointment, on account of the great latitude of his religious principles, had been successfully urged by some ecclesiastic member of the Board of Longitude. In 1773 the Royal Society awarded Priestley the Copley medal for a remarkable paper entitled "Observations on Different Kinds of Air," and in that year he became librarian and literary companion to the Earl of Shelburne (afterward Marquis of Lansdowne), and thereby secured special advantages in the pursuit of his scientific researches.

With respect to his departure from Leeds, he expressed himself as having been very happy there "with a liberal, friendly, and harmonious congregation, to whom my services (of which I was not sparing) were very acceptable. Here I had no unreasonable prejudices to contend with, so that I had full scope for every kind of exertion, and I can truly say that I always considered the office of a Christian minister as the most honorable of any upon earth, and in the studies proper to it I always took the greatest pleasure."

During the next five years he published as many volumes describing the results of important experiments on air. After investigating the properties of nitric oxide, and applying it to the analysis of air, Priestley, in 1774, discovered and carefully studied oxygen, which he obtained by the action of heat upon the red oxide of mercury. He was the first to prepare and study sulphuric acid, carbonic oxide, nitrous oxide, hydrochloric acid (*marine acid air*), and the fluoride of silicon, and carried out important researches on the properties of hydrogen, and of other gases previously but little known. His great quickness of perception and power of experiment led him to the achievement of many novel and important results. But one cannot help contrasting his somewhat random search after new discoveries with the close logical reasoning and philosophic spirit which guided and pervaded the remarkable researches of him whose departure from among us since the last gathering of this Association is so universally deplored—of the great discoverer of the universal law of the conversion of energy, James Prescott Joule. I could not add to the judicious and graceful reference to his work which Sir Henry Roscoe was privileged to make, in the last year of that philosopher's valuable life, when presiding over the recent meeting of the Association in the town which gloried in numbering Joule among its citizens. But I may, perhaps, be permitted to express the sanguine hope that the desire of the scientific world to secure the establishment of an international memorial fitly commemorative of his great life work may be realized in the most ample manner.

The wide scope of the admirable discourse delivered by Owen in this town thirty-two years ago affords an interesting illustration of the delight which men whose best energies are devoted to the cultivation of one particular branch of science take in the results of the labors of their fellow-workers in other departments, and in their achievements in contributing to the general advancement of our knowledge of Nature's laws and of their operations. It is to this bond of intimate union between all workers in pure science that we owe the instructive reviews of the progress made in different departments of science, with which we have often been presented at our annual gatherings. On the other hand, those men, from time to time selected to fill the distinguished office of president whose lives have been mainly devoted to the practical utilization of the results of scientific research, and to the extension in particular directions of the consequent resources of civilization, seize with keen pleasure the opportunity afforded them of directing attention to the triumphs achieved in the application, to the purposes of daily life, of the great scientific truths established by such illustrious laborers in the fields of pure science as Newton, Dalton, Faraday, and Joule. The wide and constantly extending domain of applied science presents, even to the superficial observer, a continually varied scene; not a year passes but some great prize falls to the lot of one or other of its explorers, and some apparently insignificant vein of treasure, struck upon but a few years back, is rapidly opened out by cunning explorers, until it leads to a mine of vast wealth, from which branch out in many directions new sources of power and might.

THE ELECTRIC TELEGRAPH.

Among the branches of science in the practical applications of which the greatest strides have been made since the Association met at Leeds in 1858, is electricity. That year witnessed the accomplishment of the first great step toward the establishment of electrical communication between Europe and America, by the laying of a telegraph cable connecting Newfoundland with Valencia. Through this cable a message of thirty-one words was shortly afterward transmitted in thirty five minutes; an achievement which, though exciting great enthusiasm at the time, scarcely afforded promise of the succession of triumphs of ocean telegraphy which have since surpassed the wildest dreams of the pioneers in the realms of applied electricity.

The development of the electric telegraph constitutes a never-failing subject of the liveliest interest. The experiments made by Stephen Gray, in 1727, of transmitting electrical impulses through a wire 700 feet long; by Watson, twenty years afterward, of transmitting frictional electricity through many thousand feet of wire, supported by a line of poles, on Shooter's Hill, in Kent; and by Franklin, who carried out a similar experiment at Philadelphia—although they were followed by many other interesting and philosophical applications of frictional electricity to the transmission of signals—were not productive of really practical results. The work of Galvani and of Volta was more fruitful of an approach to practical telegraphy in the hands of Sommering and of Coxe, while the researches of Oersted, of Ampere, of Sturgeon, and of Ohm, and especially the discoveries of volta-electric induction and magneto-electricity by Faraday, paved the way

for the development of the electric telegraph as a practical reality by Cooke and Wheatstone in 1837. How remarkable the strides have been in the resources and powers of the telegraphist since that time is demonstrated by a few such facts as these: the first needle instrument of Cooke and Wheatstone transmitted messages at the rate of four words per minute, requiring five wires for that purpose; six messages are now conveyed by one wire, at ten times that speed, and news is dispatched at the rate of 600 words per minute. Duplex working, which more than doubled the transmitting power of a submarine cable, was soon eclipsed by the application of Edison's quadruplex working, which has in its turn been surpassed by the multiplex system, whereby six messages may be sent independently, in either direction, on one wire. When last the British Association met in Leeds, submarine telegraphy had but just started into existence. Thirty years later the accomplished president of the Mechanical Section informed us, at our meeting at Bath, that 110,000 miles of cable had been laid by British ships, and that a fleet of nearly forty ships was occupied in various oceans in maintaining existing cables and laying new ones.

The important practical achievements by which most formidable difficulties have been surmounted, step by step, in the successive attainment of the marvelous results of our day, have exerted an influence upon the advancement, not merely of electrical science, but also of science generally and of its applications, fully equal to that which they have exercised upon the development of commerce and of the intercourse between the nations of the earth.

OCEAN TELEGRAPHY.

Thus the laying of the earliest submarine cables, between 1851 and 1855, led Sir W. Thomson, in conference with Sir George Stokes, to work out the theory of signaling in such cables, by utilizing the mathematical results arrived at by Fourier in his investigation of the propagation of heat waves. The failure of the first Atlantic cable led to the survey of the bottom of the Atlantic, which was the forerunner of deep sea explorations, culminating in the work of the Challenger expedition, and opening up new treasures of knowledge scarcely dreamt of when last the British Association met at Leeds. To the difficulties connected with the early attempts at submarine telegraphy, and the determination with which Thomson drove home the lessons learned, we owe the systematic investigations into the causes of the variations in the resistance of copper conductors, and the consequent improvements in the metallurgy of copper, which led to the realization of the high standard of purity of metal essential for the efficient working of telegraphic systems, and also to the extensive utilization of electricity in the production of pure copper.

ELECTRICAL MEASUREMENTS.

The rare combination of originality in powers of research and perspicuity in mathematical reasoning, with inventive and constructive genius, for which Thomson has so long been pre-eminent, has placed at the disposal of the investigator of electric science and of the practical electrician instruments of measurement and record which have been of incalculable value, and which owe their origin to the theoretical conclusions arrived at by him in his researches into the conditions to be fulfilled for the attainment of practical success in the construction and employment of submarine cables. The mirror galvanometer, the quadrant electrometer, the siphon recorder, and the divided ring electrometer, are illustrations of the valuable outcome of Thomson's labors. The combination of the last named instrument with sliding resistance coils has rendered possible the accurate subdivision of a potential difference into 10,000 equal parts. The general use of condensers in connection with cable signaling, due to Varley's application of them for signaling through submerged cables with induced short waves, was instrumental in establishing the fact that all electrostatic phenomena are simply the result of starting an electric current of known short duration round a closed circuit. The practical application of the Wheatstone bridge led to numerous important mathematical investigations, and induced Clerk Maxwell to devise a new mode of applying determinants to the solution of the complicated electrical problems connected with networks of conductors.

The necessity for the universal recognition of an electrical unit of resistance led to the establishment, in 1860, of the Electrical Standards Committee of the British Association, whose long succession of important annual reports was instrumental in most important developments of theoretical electricity, and, indeed, served to open up the whole science of electrical measurement. Matthiessen's important investigations of the electrical behavior of metals and their alloys, and the preparation and properties of pure iron, were the outcome of the commercial demand for a practically useful standard of electrical resistance; while Latimer Clark's practical standard of electromotive force, the mercurous sulphate cell, became invaluable to the worker in pure electrical research. The unit of resistance established by the British Association Committee received, in 1866, most important scientific application at the hands of Joule, who, by measuring the rate of development of heat in a wire of known resistance by the passage of a known current, obtained a new value of the mechanical equivalent of heat. This value differed by about 1·3 per cent. from the most accurate results arrived at by his experiments on mechanical friction, a difference which eventually proved to be exactly the error in the British Association unit of resistance; so that the true value of the unit of resistance, or ohm, was determined by Joule fifteen years before the result was achieved by electricians. Clerk Maxwell's remarkable electro-magnetic theory of light was put to the test, through the aid of the British Association unit of resistance, by Thomson, in determining the ratio of the electro-magnetic unit to electro-static unit of quantity. Many other most interesting illustrations might be given of the invaluable aid afforded to purely scientific research by the practical results of the development of electrical science, and of the constant co-operation between the science student and the practical worker.

ELECTRIC LIGHTING.

No one could, more fully than the late Sir William Siemens, have maintained, as he did in his admirable address at our meeting in Southampton in 1882, that we owe most of the rapid progress of recent times to the man of science who partly devotes his energies to the solution of practical problems, and to the practitioner who finds relaxation in the prosecution of purely scientific inquiries. Most assuredly both these classes of the world's benefactors may with equal right lay claim to rank the name of Siemens among those whom they count most illustrious.

In that highly interesting and valuable address delivered little more than a year before his sudden untimely removal from among us, the numerous important subjects discussed by him included not a few which he had made peculiarly his own in the wide range embraced by his enviable power of combining scientific research with practical work. Prominent among these were the applications of electric energy to lighting and heating purposes, and to the transmission of power, to the future development of which his personal labors very greatly contributed.

Siemens referred to the passing of the first Electric Lighting Bill, in the year of his presidency, as being designed to facilitate the establishment of electric installations in towns; but the anxiety of the government of that day to protect the interests of the public through local authorities led to the assignment of such power to these over the property of lighting companies, that the utilization of electric lighting was actually delayed for a time by those legislative measures. There can now be no doubt, however, that this delay has really been in the interests of intending suppliers, and of users of the electric light, as having afforded time for the further development of practical details, connected with generation and distribution, which was vital to the attainment of a fair measure of initial success. The subsequent important modification of legislation on the subject of electric lighting, together with the practical realization of comparatively economical methods of distribution, the establishment of fairly equitable arrangements between the public and the lighting companies, and the apportionment, so far as the metropolis is concerned, of distinct areas of operation to different competing companies, have combined to place electric lighting in this country at length upon some approach to a really sound footing, and to give the required impetus to its extensive development. Nine companies either are now, or will very shortly be, actually at work supplying, from central stations, districts of London comprising almost the entire western and northwestern portions of the metropolis. As regards other parts of England, there are already twenty-seven lighting stations actually at work in different towns, besides others in course of establishment, and many more projected. The town of Leeds has not failed to give serious attention to the subject of utilizing the electric light, and, although no general scheme has yet been adopted, the electricians who now visit this town will rejoice to see many of its public buildings provided with efficient electric illumination.

While the prediction made by Siemens, eight years ago, that electric lighting must take its place with us as a public illuminant has thus been already, in a measure, fulfilled, important progress is being continuously made by the practical electrician in developing and perfecting the arrangements for the generation of the supply, its efficient distribution from centers, and its delivery to the consumer in a form in which it can be safely and conveniently dealt with and applied at an outlay which even now does not preclude a considerable section of the public from enjoying the decided advantages presented by electric lighting over illumination by coal gas. Yet our recent progress in this direction, encouraging though it has been, is insignificant as compared with the strides made in the application of electric lighting in the United States, as may be gauged by the fact that while in America the number of arc lamps in use in April of this year was 235,000, and of glow lamps about three millions, there are at present only about one-tenth the number of the latter, and one-hundredth the number of arc lamps, in operation in England.

In some important directions we may, however, lay claim to rank foremost in the application of the electric light; thus our large passenger ships and our war ships are provided with efficient electrical illumination. To the active operations of our navy the electric light has become an indispensable adjunct; and our system of coast defense, by artillery and submarine mines, is equally dependent for its thorough efficiency upon the applications of electricity in connection with range finding, with the arrangement and explosion of mines, and with the important auxiliary in attack and defense, the electric light, which, while so arranged, at the operating stations, as to be protected against destruction by artillery fire, and difficult of detection by the enemy, is available at any moment for affording invaluable information and important assistance and protection.

Other important applications of the electric light, such as its use as a lighthouse illuminant, for the lighting of main roads in coal mines, where its value is being increasingly appreciated, and even for signaling purposes in mid air, through the agency of captive balloons, are continually affording fresh demonstrations of the value of this particular branch of applied electric science.

At the Electrical Exhibition at Vienna in 1883, where not long before the lamented death of Siemens I had the honor of serving as one of his colleagues in the representation of British interests, the progress which had been made in the construction of electrical measuring instruments since the French Exhibition and the Electrical Congress, two years before, was very considerable. The advance in this direction has been enormous since that time; but although the practical result of Thomson's and of Carlew's important work has been to supply us with trustworthy electrical balances and voltmeters, while efficient instruments have also been made by other well known practical electricians, we have still to attain results in all respects satisfactory in these indispensable adjuncts to the commercial supply and utilization of electric energy.

In connection with this important subject the recent completion of the Board of Trade standardizing laboratory, established for the purposes of arriving at and maintaining the true values of electrical units, and of securing accuracy and uniformity in the manufacture of instruments supplied by the trade for electrical measurements, may be referred to with much satisfaction as a practical illustration of official recognition of the firm root which the domestic and industrial utilization of electric energy has taken in this country.

THE TELEPHONE.

The achievements of the telephone were referred to by Siemens in glowing terms eight years ago; but the results then attained were but indications of the direction in which telephonic intercommunication was destined speedily to become one of the most indispensable of present applications of electricity to the purposes of daily life. Preece, in speaking at Bath two years ago of the advances made in applied electricity, showed that the impediments to telephonic communication between great distances had been entirely overcome; and now, although considerably behind America and France in the use of the telephone, we are rapidly placing ourselves upon speaking terms with our friends throughout the United Kingdom. The operations of the National Telephone Company well illustrate our progress in telephonic intercommunication. That company has now 22,743 exchange lines, besides nearly 5,000 private lines; its exchanges number 272, and its call offices 526. The number of instruments under rental in England has now reached 99,000; but, important as this figure is compared to the use of the telephone a very few years ago, it sinks into insignificance by the side of the number of instruments under rental in America, which at the beginning of the present year had reached 222,430, being an increase of 16 675 over the number in 1889. Only thirteen years have elapsed since the telephone was first exhibited as a practically workable apparatus to members of the British Association at their Plymouth meeting, and the number of instruments now at work throughout the world may be estimated as considerably exceeding a million.

ELECTRIC TRANSMISSION OF POWER.

The successful transmission of the electric current, and the power of control now exercised over the character which electrically transmitted energy is made to assume, are not alone illustrated by the efficiency of the arrangements already developed for the supply of the electric light from central stations. Siemens dwelt upon this subject at Southampton with the ardent interest of one who had made its development one of the objects of his energetic labors in later years, and also with a prophet's prognostications of its future importance. In speaking of the electric current as having entered the lists in competition with compressed air, the hydraulic accumulator, and the quick-running rope driven by water power, Siemens pointed out that no further loss of power was involved in the transformation of electrical into mechanical energy than is due to friction, and to the heating of the conducting wires by the resistance they oppose, and he showed that this loss, calculated upon data arrived at by Dr. John Hopkinson and by himself, amounted at the outside to 38 per cent. of the total energy. Subsequent careful researches by the brothers Hopkinson have demonstrated that the actual loss is now much less than it was computed at in 1885, as much as 87 per cent. of the total energy transmitted being realizable at a distance, provided there be no loss in the connecting leads used.

The Paris Electric Exhibition of 1881 already afforded interesting illustrations of the performance of a variety of work by power electrically transmitted, including a short line of railway constructed by the firm of Siemens, which was a further development of the successful result already attained in Berlin by Werner Siemens in the same direction, and was, in its turn, surpassed by the considerably longer line worked by Messrs. Siemens at the Vienna Exhibition two years later. Various short lines which have since then been established by the firm of Siemens are well known, and one of the latest public acts in the valuable life of Siemens was to assist at the opening of the electric tramway at Portrush, in the installation of which he took an active part, and where the idea, so firmly rooted in his mind from the date of his visit to the Falls of Niagara, in 1876, of utilizing water power for electrical transmission—a result first achieved on a small scale by Lord Armstrong—was more practically realized than had yet been the case.

ELECTRIC RAILWAYS.

Since that time Ireland has witnessed a further application of electricity to traction purposes, and of water power to the provision of the required energy, in the working of the Bessbrook and Newry tramway, while London at length possesses an electric railway, three miles in length, to be very shortly opened, which will connect the City with one of the southern suburbs through a tram subway, and, although including many sharp curves and steep gradients, will be capable of conveying one hundred passengers at a time, at speeds varying from thirteen to twenty-four miles per hour. During the past year a regular service of tram cars has been successfully worked, through the agency of secondary batteries, upon part of one of the large tramways of North London, with results which bid fair to lead to an extensive development of this system of working. The application of electricity to traction purposes has, however, received far more important development in the United States. At the commencement of this year there were in operation in different States 200 electrical tramroads, chiefly worked upon the Thomson-Houston and the Sprague systems, and having a collective length of 1,641 miles, with 2,346 motor cars traveling thereon. Further extensions are being rapidly made; thus, one company alone has 39 additional roads, of a collective length of 385 miles, under construction, to be worked through the agency of storage batteries.

The idea cherished by Siemens, and enlarged upon by him in more than one interesting address, of utilizing the power of Niagara, appears about to be realized, at any rate in part, as a large tract of land has been recently acquired by a powerful American association about a mile distant from the falls, with a view to the erection of mills for utilizing the power, which it is also proposed to transmit to distant towns; and an international commission, with Sir William Thomson at its head, and with Mascart, Turrettini, Coleman Sellers, and Unwin as members, will carefully consider the problems involved in the execution of this grand scheme.

The application of electric traction to water traffic first successfully demonstrated in 1883, is receiving gradual development, as illustrated by the considerable number of pleasure boats which may now be seen on the Upper Thames during the boating season, and in connection with which Prof. George Forbes proposed at our meeting last year that stations for charging the requisite cells, through the agency of water power, should be established at the many weirs along the river, so as to provide convenient electric coaling stations for the river pleasure fleet.

Electrically transmitted energy was first applied in Germany to haulage work in mines by the firm of Siemens some years ago, and great progress has since been achieved herein on the Continent and in America. Comparatively little has been accomplished in this direction in England , but it is very interesting to note, on the present occasion, that the first successful practical application of electricity in this country to pumping and underground haulage work was made in 1887, in this neighborhood, at the St. John's Colliery, at Normanton, where an extensive installation, carried out by Mr. Immisch, so well known in connection with electric launches, is furnishing very satisfactory results in point of economy and efficiency. The gigantic installations existing for the same purposes in Nevada and California afford remarkable illustrations of the work to be accomplished in the future by electrically transmitted energy.

ELECTRIC METALLURGY.

Among the many subjects of importance studied by Joule with the originality and thoroughness characteristic of his work, was the application of voltaic electricity to the welding and fusion of metals. Thirty-four years ago he published a most suggestive paper on the subject, in which, after dealing with the difficulties attending the operation of welding, and of the interference of films of oxide, formed upon the highly heated iron surface, with the production of perfect welds either under the hammer or by the methods of pressure (of which he then predicted the application to large masses of forged iron), he refers to the possibility of applying the calorific agency of the electric current to the welding of metals, and describes an operation witnessed by him in the laboratory of his fellow-laborer, Thomson, of fusing together a bundle of iron wires by transmitting through them, when embedded in charcoal, a powerful voltaic current. Joule afterward succeeded in fusing together a number of iron wires with the current of a Daniell battery, and in welding together wires of brass and steel, platinum and iron, etc. In discussing the question of the amount of zinc consumed in a battery for raising a given amount of iron to the temperature of fusion, he points out that the same object would probably be more economically attained by the use of a magneto-electric machine, which would allow the heat to be provided by the expenditure of mechanical force, developed in the first instance by the expenditure of heat; and he indicates the possibility of arranging machinery to produce electric currents which shall evolve one-tenth of the total heat due to the combustion of the coal used, so that 5,000 grains of coal applied through that agency would suffice for the fusion of one pound of iron. The successful practical realization of Joule's predictions in regard to the application of electric currents, thus developed, to the welding of iron and steel, and to analogous operations, through the agency of the efficient machines devised by Prof. Elihu Thomson, was demonstrated to the members of the Association by Prof. Ayrton, of Bath, two years ago, and was shown upon a larger scale to visitors at the Paris Exhibition last year, and recently to highly interested audiences in London by our late President, Sir Frederick Bramwell. The latter demonstrated that the production of iron welds by means of the Thomson machines was accomplished nearly twice as rapidly as by expert craftsmen; the perfection of the welds being proved by the fact that the strength of bars broken by tensile strains at the welds themselves was about 92 per cent. of the strength of the solid metal. At the Crewe Works Mr. Webb is successfully applying one of these machines to a variety of welding work. The rapidity with which masses of metal of various dimensions are raised in those machines to welding heat is quite under control; the heat is applied without the advent of any impurities, as from fuel, and the speed of execution of the welding operation reduces to a minimum the time during which the heated surfaces are liable to oxidize. With such practical advantages as these, this system of electric welding bids fair to receive many useful applications.

Another very simple system of electric welding, especially applicable to thin iron and steel sheets, hoops, etc., has been cotemporaneously elaborated in Russia by Dr. Bernados, and is already being extensively used. The required heat of the surfaces to be welded is developed by connecting the metal with the negative power of the dynamo machine, or a battery of accumulators, the circuit being completed by applying a carbon electrode to the parts to be heated; the reducing power of the carbon is said to preserve the heated metal surfaces from oxidation during the very brief period of heating. This mode of operation appears to have been practiced upon a small scale, some years ago, by Sir William Siemens, to whom we also owe the first attempt to practically apply electric energy to the smelting of metals.

In his address in 1882 he referred to some results attained with his small electrical furnace, and pointed out that, although electric energy could, obviously, not compete economically with the direct combustion of fuel for the production of ordinary degrees of heat, the electric furnace would probably receive advantageous application for the attainment of temperatures exceeding the limits (about 1800° C.) beyond which combustion was known to proceed very sluggishly. This prediction appears to have been already realized through the important labors of Messrs. Cowles, who some years ago attacked the subject of the application of electricity to the achievement of metallurgic operations with the characteristic vigor and fertility of resource of our transatlantic brethren. After very promising preliminary experiments, they succeeded, in 1885, at Cleveland, Ohio, in maturing a method of operation for the production of aluminum-bronze, ferro-aluminum, and silicium-bronze, with results so satisfactory as to lead to the erection of extensive works at Lockport, N. Y., where three dynamo machines, each supplying a current of about 3,000 amperes, are worked by water power, through the agency of turbines, each of 500 horse power, eighteen electric furnaces being now in operation for the production of aluminum alloys. These achievements have led to the establishment of similar works in North Staffordshire, where a gigantic dynamo machine has been erected, furnishing a current of 5,000 amperes, with an E. M. F. of 50 to 60 volts. The arrangements of the electrodes in the furnaces, the preparation of the furnace charges (consisting of mixtures of aluminum ore with charcoal and with the particular granulated metal with which the aluminum is to become alloyed at the moment of its elimination from the ore); the appliances for securing safety in dealing with the current from the huge dynamo machine, and many other details connected with this new system of metallurgic work, possess great interest. Various valuable copper and aluminum alloys are now produced by alloying copper itself with definite proportions of the copper alloy, very rich in aluminum, which is the product of the electric furnace. The rapid production in large quantities of ferro-aluminum—which presents the aluminum in a form suitable for addition in definite proportions to fluid cast iron and steel—is another useful outcome of the practical development of the electric furnace by Messrs. Cowles.

The electric process of producing aluminum alloys has, however, to compete commercially with their manufacture by adding to metals, or alloys, pure aluminum produced by processes based upon the method originally indicated by Oersted in 1824, successfully carried out by Wöhler three years later, and developed into a practical process by H. Ste Claire Deville in 1854—namely, by eliminating aluminum from the double chloride of sodium and aluminum in the presence of a fluoride, through the agency of sodium. An analogous process, indicated in the first instance by H. Rose—namely, the corresponding action of sodium upon the mineral cryolite, a double fluoride of aluminum and sodium—has also been recently developed at Newcastle, where the first of these methods was applied, upon a somewhat considerable scale, in 1860, by Sir Lowthian Bell, but did not then become a commercial success, mainly owing to the costliness of the requisite sodium. As the cost of this metal chiefly determines the price of the aluminum, technical chemists have devoted their best energies to the perfection and simplification of methods for its production, and the success which has culminated in the admirable Castner process constitutes one of the most interesting of recent illustrations of the progress made in technical chemistry, consequent upon the happy blending of chemical with mechanical science, through the labors of the chemical engineer.

Those who, like myself, remember how, between forty and fifty years ago, a few grains of sodium and potassium were treasured up by the chemist, and used with parsimonious care in an occasional lecture experiment, cannot tire of feasting their eyes on the stores of sodium ingots to be seen at Oldbury as the results of a rapidly and dexterously executed series of chemical and mechanical operations.

ALUMINUM IN IRON AND STEEL.

The reduction which has been effected in the cost of production of aluminum through this and other processes, and which has certainly not yet reached its limit, can scarcely fail to lead to applications of the valuable chemical and physical properties of this metal so widespread as to render it as indispensable in industries and the purposes of daily life as those well known metals which may be termed domestic, even although and, indeed, for the very reason that, its association with many of these, in small proportion only, may suffice to enhance their valuable properties or to impart to them novel characteristics.

The Swedish metallurgist, Wittenström, appears to have been the first to observe that the addition of small quantities of aluminum to fused steel and malleable iron had the effect of rendering them more fluid, and, by thus facilitating the escape of entangled gases, of ensuring the production of sound castings without any prejudicial effect upon the quality of the metal. The excellence of the so called Mitis castings, produced in this way, appears thoroughly established, and the results of recent important experiments seem to be opening up a field for the extensive employment of aluminum in this direction, provided its cost becomes sufficiently reduced. The valuable scientific and practical experiments of W. J. Keep, James Riley, R. Hadfield, Stead, and other talented workers in this country and the United States, are rapidly extending our knowledge in regard to the real effects of aluminum upon steel, and their causes. Thus it appears to be already established that the modifications in some of the physical properties of steel resulting from the addition of that metal are not merely ascribable to its actual entrance into the composition of the steel, but are due, in part, to the deoxidation by aluminum of some proportion of iron oxide which exists distributed through the metal, and prejudicially affects its fluidity when melted. In the latter respect, therefore, the influence exerted by aluminum, when introduced in small proportions into malleable iron and steel, appears to be quite analogous to that of phosphorus, silicium, or lead when these are added in small proportions to copper and certain of its alloys, the deoxidation of which, through the agency of those substances, results in the production of sound castings of increased strength and uniformity. It is only when present in small proportion in the finished steel that aluminum increases the breaking strain and elastic limit of the product.

The influence of aluminum, when used in small proportion, upon the properties of gray and white cast iron, is also of considerable interest, especially its effect in promoting the production of sound castings, and of modifying the character of white iron in a similar manner to silicium, causing the carbon to be separated in the graphitic form ; with this difference—that the carbon appears to be held in solution until the moment of setting of the liquid metal, when it is instantaneously liberated, with the result that the structure of the cast metal and distribution of the graphite are perfectly uniform throughout.

MANGANESE, CHROMIUM, TUNGSTEN, COPPER AND NICKEL IN IRON AND STEEL.

The probable beneficial connection of aluminum with the industries of iron and steel naturally directs attention to the great practical importance, in the same direction, which has already been acquired, and promises to be in increasing measure attained, by certain other metals which, for long periods succeeding their discovery, have either been only of purely scientific interest and importance, or have acquired practical value in regard to their positions in a few directions quite unconnected with metallurgy. Thus great interest attaches to the influence of the metals manganese, chromium, and tungsten upon the physical properties of steel and iron.

The name of Mushet is most prominently associated with the history of manganese in its relations to iron and steel. Half a century ago David Mushet carried out very instructive experiments on the influence exerted upon the properties of steel by the presence of manganese ; and to Robert Mushet we owe the invaluable experiments leading to his suggestion to use manganese in the production of steel by the Bessemer process, which at once smoothed the path to the marvelously rapid and extensive development of the applications of steel produced by that classic method, and subsequently by the open-hearth or Siemens-Martin process—a development which has recently received its crowning illustration in the completion of one of the grandest of existing triumphs of engineering science and constructive skill—the Forth Bridge.

Robert Hadfield has recently contributed importantly to our knowledge of the relations of manganese to iron. His systematic study of the subject has revealed some very remarkable variations in the physical properties of so-called manganese steel, according to the proportions of manganese which it contains. Thus, while the existence in steel of proportions ranging from 0·1 up to about 2·75 per cent. improves its strength and malleability, it becomes brittle if that limit is exceeded, the extreme of brittleness being obtained with between 4 and 5 per cent. of manganese ; if, however, the percentage is increased to not less than 7, and up to 20, alloys of remarkable strength and toughness are obtained. Castings of high manganese steel, such as wheel tires, combine remarkable hardness with toughness. Even if the proportion of manganese is as high as 20 per cent. in a steel containing 2 per cent. of carbon, it can be forged; whereas it is very difficult to forge a steel of ordinary composition containing as much as 2·75 per cent. of carbon. Another remarkable peculiarity of the high manganese steel is its behavior when quenched in water, Instead of the heated metal being hardened and rendered brittle by the sudden cooling, like carbon steel, its textile strength and its toughness are increased; so that water quenching is really a toughening process, as applied to the manganese alloy ; and an interesting feature connected with this is that the colder the bath into which the highly heated metal is plunged, the tougher is the product. The curious effect of manganese in reducing, and even destroying, the magnetic properties of iron was already noticed by Rinmann nearly 120 years ago ; one result of Hadfield's important labors has been to place in the hands of such eminent physicists as Thomson, John Hopkinson, and Reinold, materials for the attainment of most interesting information respecting the electrical and other physical characteristics of manganese steel. Hopkinson, from experiments with a sample of steel containing 12 per cent. of manganese, estimated that not more than 9 out of the 86 per cent. of the iron composing the mass was magnetic, and he considered that the manganese enters into that which must, for magnetic purposes, be regarded as the molecule of iron, completely changing its properties, a fact which must have great significance in any theory regarding the nature of magnetization. The great hardness of manganese steel, and the consequent difficulty of dealing with it by means of cutting tools, constitute at present the chief impediments to its technical applications in many directions; but where great accuracy of dimensions is not required, and where great strength is an essential, it is already put to valuable uses.

The importance of manganese in connection with the metallurgy of iron and steel is in a fair way of finding its rival in that of the metal chromium, the employment of which, as an alloy with steel, was first made the subject of experiment in 1821, by Berthier, who was led by the important experiments of Faraday and Stoddart, then just published, to endeavor to alloy chromium with steel, and obtained good results by fusing steel together with a rich alloy of chromium and iron, so as to introduce about 15 per cent. of the former into the metal. Further small experiments were made the year following by Faraday and Stoddart, in the same direction; but chrome steel appears to have been first produced commercially at Brooklyn, N. Y., sixteen years ago Ten years later its manufacture had become developed in France, and the varieties of chrome steel produced in the Loire district now receive important and continually extending applications, on account of their combining comparative hardness with high tenacity, and only little loss in ductility, and of their acquiring great closeness of structure when tempered.

The influence of chromium upon the character of steel differs in several marked respects from that exercised by managanese ; thus, chrome steels weld badly, or not at all, whereas manganese steels weld very readily, and work under the hammer better than ordinary carbon steel. Again, the remarkable influence of manganese upon the magnetic properties of steel and iron is not shared by chromium. Chrome steel has for some time been a formidable rival of the very highest qualities of carbon steel produced for cutting tools, and of the valuable tungsten steel which we owe to Robert Mushet. The great hardness, high tenacity, and exceeding closeness of structure possessed by suitably tempered steel containing not more than from 1 to 1·5 per cent. of chromium and from 0·8 to 1 per cent. of carbon renders this material invaluable for war purposes; cast projectiles, when suitably tempered, have penetrated compound steel and iron plates over nine inches in thickness, such as are used upon armored ships of war, without even sustaining any important change of form. The proper tempering of these projectiles necessitates their being produced hollow; their cavities or chambers are only of small capacity, but the charge of violent explosive which they can contain, and which can be set into action without the intervention of fuse or detonating

appliance, suffices to tear these formidable punching tools into fragments as they force their way irresistibly through the armored side of a ship, and to violently project those fragments in all directions, with fearfully destructive effects. The employment of chromium as a constituent of steel plates used for the protection of ships of war is already being entered upon, and the influence exerted by the presence of that metal in small quantities in steel employed in the construction of guns is also at present a subject of investigation. At Crewe, Mr. F. Webb has for some time past used chromium, with considerable advantage, in the production of high quality steels for railway requirements.

The practical results attained by the introduction of copper and of nickel as components of steel have also recently attracted much attention. At the celebrated French steel works of M. Schneider, at Creusot, the addition of a small percentage of copper to steel used for armor plates and projectiles is practiced, with the object of imparting hardness to the metal without prejudice to its toughness. James Riley has found that the presence of aluminum in very small quantities facilitates the union of steel with a small proportion of copper, and that the latter increases the strength but does not improve the working qualities of steel. With nickel, Riley has obtained products analogous in many important respects to manganese steel; the remarkable differences in the physical properties of the manganese alloys, according to their richness in that metal, are also shared by the nickel alloys, some of these being possessed of very valuable properties; thus it has been shown by Riley that a particular variety of nickel steel presents to the engineer the means of nearly doubling boiler pressures, without increasing weight or dimensions. He has, moreover, found the coexistence of manganese in small quantity with nickel in the alloy to contribute importantly to the development of valuable physical properties.

The careful study of the alloys of aluminum, chromium, manganese, tungsten, copper, and nickel, with iron and with steel, so far as it has been carried, with especial reference to the influence which they respectively exercise upon the salient physical properties of those materials even when present in them in only very small proportions, has demomonstrated the importance of a more searching or complete application of chemical analysis than hitherto practiced, to the determination of the composition of the varieties of steel which practical experience has shown to be peculiarly adapted to particular uses. It appears, indeed, not improbable that certain properties of these, which have been ascribed to slight variations in the proportion or the condition of the constituent carbon or in the amounts of silicium, phosphorus and manganese which they contain, may sometimes have been due to the presence in minute quantities of one or other of such metals as those named, and to the effects which they produce, either directly or indirectly by modifying or counteracting the effects of the normal constituents of steel. The important part now played by manganese in steel manufacture is an illustration of the comparatively recent results of research, and of practical work based on research, in these directions, and the effects of the presence in steel of only very small quantities of some of the other metals named are already, as I have pointed out, being similarly understood and utilized.

RESEARCHES RESPECTING THE PHYSICAL PROPERTIES OF IRON AND STEEL.

Such systematic researches as those upon which Osmond, Roberts-Austen, and many other workers have been for some time past engaged may make us acquainted with the laws which govern the modifications effected in the physical characteristics of metals by alloying these with small proportions of other metals. The suggestion of Roberts Austen, that such modifications may have direct connection with the periodic law of Mendeleef, which may furnish explanations of the causes of specific variations in the properties of iron and steel, has been followed up energetically by Osmond, who has experimentally investigated the thermal influence upon iron of the elements phosphorus, sulphur, arsenic, boron, silicium, nickel, manganese, chromium, copper, and tungsten. He regards his results as being quite confirmatory of the soundness of Roberts-Austen's suggestion, as they demonstrate that foreign elements having atomic volumes lower than iron tend to make it assume or preserve the particular molecular form in which it has itself the lowest atomic volume, while the converse is the case for the foreign elements of high atomic volume. An analogous influence was found to be exerted by those two groups of elements upon the permanent magnetization of steel.

Captivating as such deductions are, those who have devoted much attention to the practical investigation of iron, steel, and other metals, cannot but feel that much caution has to be exercised in drawing broad conclusions from the results of such researches as these. Like the investigations recently made with the object of ascertaining the condition in which carbon exists in steel, and the part played by it in determining the modifications in the properties developed in that material by the influence of temperature and of work done upon it, they are surrounded by formidable difficulties, arising from the practical impossibility of altogether eliminating the disturbing influences of minute quantities of foreign elementary bodies, coexisting in the metal operated upon with those whose effects we desire to study. Certain it is, however, that by acquiring an accurate acquaintance with the composition of varieties of iron and steel exhibiting characteristic properties; by persevering in the all-important work of systematic practical examination of the mechanical and physical peculiarities developed in iron and steel of known composition by their association with one or more of the rarer metals in varied proportions, and by the further prosecution of chemical and physical research in such directions as those which have already been fruitful of most instructive results, such talented laborers as Chernoff, Osmond, Roberts-Austen, Barus and Strouhal, Hadfield, Keep, James Riley, Stead, Turner, and others, cannot fail to contribute continually to the development of improvements equaling in importance those already attained in the production, treatment, and methods of applying cast iron, malleable iron, and steel, or alloys equivalent to steel in their qualities.

The causes of the variations in the physical properties of steel produced by the so-called hardening, annealing, and tempering processes were for very many years a fruitful subject of experimental inquiry, as well as of theoretical speculation with regard to the condition in which the carbon is distributed in steel, according to whether the metal is hardened or annealed, or in an intermediate, tempered state. Recent researches have made our knowledge in the latter direction fairly precise; as yet, however, we are only on the track of definite information respecting the nature and extent of connection between the physical peculiarities of steel in those different conditions and the established differences in the form and manner in which the carbon is disseminated through it.

The careful systematic study of the modifications developed in certain physical properties of iron and steel by gradual changes of temperature between fusion of the metal and the normal temperature has shown those modifications to be governed by a constant law, and that at certain critical temperatures special phenomena present themselves. This important subject, which was so clearly brought before the Association last year in the interesting lecture of Roberts-Austen, has been and is still being pursued by accomplished workers, among whom the most prominent is F. Osmond. The phenomenon of recalescence or the reglowing of, or liberation of heat in, iron and steel at certain stages during the cooling process, first noticed by Gore, and examined into by Barrett, appears to be the result of actual chemical combination between the metal and its contained carbon at the particular temperature attained at the time; while the absorption of heat, demonstrated by the arrest in rise of temperature during its continuous application to the metal, is ascribed to the elimination, within the mass, of carbon as an iron-carbide perfectly stable at low temperatures. The pursuit of a well devised system of experimental inquiry into this subject has led Osmond to propound theories of the hardening and tempering of steel, which are at present receiving the careful study of physicists and chemists, and cannot fail to lead to further important advancement of our knowledge of the true nature of the influence of carbon upon the properties of iron.

Another important subject connected with the treatment of masses of steel, and with the influence exercised upon their physical characteristics by the processes of hardening and tempering, and by submitting them to oft-repeated concussions or vibrations, or frequent or long-continued strains, is the development and maintenance, or gradual disappearance, of internal stresses in the masses—one of the many important subjects to which attention was directed by Dr. Anderson, the Director-General of Ordnance Factories, in his very suggestive address to the Mechanical Section last year. This question is one of especial interest to the constructor of steel guns, as the powers of endurance of these do not simply depend upon the quality of the material composing them, but are very largely influenced by the treatment which it receives at the hands of the gunmaker. Indeed, the highest importance attaches to the processes which are applied to the preliminary preparation of the individual parts of which the gun is constructed, and to the putting together of these so as to insure their being and remaining in the physical condition best calculated to assist each other in securing for the structure the power of so successfuly resisting the heavy strains to which it has to be subjected as to suffer little alteration other than that due to the superficial action of the highly heated products of explosion of the charges fired in the gun. The development of internal strains in objects of steel, especially by the hardening and tempering processes, or by their exposure to conditions favorable to unequal cooling of different parts of the mass, has long been a subject of much trouble and of experimental inquiry in connection with many applications of steel. Systematic experiments of the kind, commenced about eighteen years ago, by the late Russian general Kalakoutsky, are now being pursued at Woolwich, with the objects of determining the nature and causes of internal stresses in steel gun-hoops and tubes, and in shells, and of thereby establishing the proper course to be adopted for avoiding, lessening, or counteracting injurious stresses, on the one hand, and for setting up stresses beneficial to the powers of endurance of guns, on the other. One method of experiment pursued, with parts of guns, is to cut narrow hoops off the forgings, after a particular treatment, which are then cut right across at one place, it being observed whether, and to what extent, the resulting gaps open or close. This important subject has also been similarly investigated by my talented old friend and fellow worker, the president this year of the Mechanical Section, Captain Andrew Noble, whose name in connection with the science and practice of artillery is familiar to us as household words.

THE APPLIANCES OF WAR.

The Crimean war taught nations many lessons of gravest import, to some of which Sir Richard Owen took occasion to call attention most impressively in the address delivered here, before the miseries of that war had become past history. The development of sanitary science, to which he especially referred, and which sprang from the bitter experience of that sad epoch, has had its parallel in the development of the science of artillery; but it would indeed be difficult to establish any parallelism between the benefits which even the soldier and the sailor have reaped from the great strides made by both these sciences. The acquisition of knowledge of the causes of the then hopelessness of gallant struggles which medical skill and self-sacrificing devotion made against the sufferings of the victims of battles and of fell diseases, as deadly as the cruelest implements of war; the application of that knowledge to the provision of the blessings of antiseptic treatment of wounds and to the intelligent utilization of disinfectants and of other valuable preventive measures, to the supply of wholesome water, of wholesome food in campaigning, of sensible clothing, and of wholesome air in hospitals, barracks, and ships—these are some few of the benefits which the soldier and the sailor have derived from the development of sanitary science, which was so powerfully stimulated by the terrible lessons learned during the long drawn out siege of Sebastopol: and it is indeed pleasant to reflect that there has been for years past most wholesome competition between nations in the enlargement of those benefits, and their dissemination among the men whose vocation it is to slay and be slain. The periodical International Congresses on Hygiene and Demography, of which we shall cordially welcome next year's assemblage in London, and whose members will deplore the absence from among them of the veteran Nestor in the science and practice of hygiene, Sir Edwin Chadwick, have afforded conclusive demonstration of the heartiness with which nations are now co-operating with a view to utilize the invaluable results attained by the successful laborers in sanitary science.

What, on the other hand, shall we say to the benefits which sailors and soldiers, in the pursuit of their calling, derive from the ceaseless costly competition among nations for supremacy in the possession of formidable artillery, violent explosives, quick-firing arms of deadly accuracy, and fearful engines which, unseen, can work wholesale destruction in a fleet? And what can we say to the benefits acquired by individual countries in return for their continuous, and sometimes ruinous, expenditures in endeavoring to maintain themselves upon an equality with their neighbors in man-killing power? The conditions under which engagements by sea or land will in the future be fought have certainly become greatly modified from those of thirty-five years ago, and the duration of warfare, even between nations in conflict who are on a fair equality of resources must become reduced; but, as regards the results of a trial of strength between contending forces, similarly equipped, as they now will be, with the latest of modern appliances only varying in detail, these must, after all, depend, as of old, partly upon accident, favored, perhaps, by a temporary superiority in equipment, partly upon the skill and military genius of individuals, and very much upon the characteristics of the men who fight the battles.

What really can be said in favor of the advances made in the appliances of war—and this is, perhaps, the view which in such a town as Leeds we should keep before our eyes to the exclusion of the dark side of the picture—is that by continuous competition in the development of their magnitude, diversity, and perfection the resources of the manufacturer, the chemist, the engineer, the electrician, are taxed to the utmost; with the very important, although incidental, results that industries are created or expanded and perfected, trades maintained and developed, and new achievements accomplished in applied science, which in time beneficially affect the advance of peaceful arts and manufactures. In these ways the expenditure of a large proportion of a country's resources upon material which is destroyed in creating destruction does substantially benefit communities, and tends to the accomplishment of such material progress by a country as goes far to compensate its people for the sacrifices which they are called upon to incur for the maintenance of their dignity among nations.

From this point of view, at any rate, it may interest members of the British Association for the Advancement of Science, and for the promotion of its applications to the welfare and happiness of mankind, to hear something of recent advances in one of the several branches of science in its applications to naval and military requirements with which, during a long and arduous official career, now approaching its close, I have become in some measure identified.

Since the meeting of the Association in this town in 1858, the progress which has been made in the regulation of the explosive force of gunpowder, so as to adapt it to the safe development of very high energy in guns presenting great differences in regard to size and to the work which they have to perform, has been most important. The different forms of gunpowder which were applied to war purposes in this and other countries until within the last few years, presented comparatively few differences in composition and methods of manufacture from each other, and from the gunpowder of our ancestors.

(To be continued.)

FLEXIBLE GELATINE CAPSULES.

By JOHN A. FORRET.

ALTHOUGH within the last few years gelatine capsules have come to be used more generally for the administration of nauseous medicines, it cannot be said that chemists and druggists are, as a rule, well acquainted with the manner in which they are manufactured. To a large extent, therefore, capsule making is still a specialty, and the inconvenience which thereby arises is often acutely felt. This is the case especially when we have to send to manufacturers for a few out-of-the way capsules which may happen to be ordered by prescription.

My experience goes to show that there is little reason why every chemist and druggist should not as readily make a dozen capsules as a dozen pills, and with the simple apparatus described below he may not only do this, but keep a small stock of the capsules in common use, while he has the satisfaction of sending out an article of his own manufacture.

As the result of many experiments, I found the following formula to yield the most satisfactory mass for flexible capsules:

Gelatine (in thin sheets)	16 oz.
Water	20 "
Glycerine	12 fl. oz.
Simple sirup	8 "

Mix the water, glycerine and sirup, and soak the gelatine in the mixture. When uniformly soft, melt in a water bath.

Capsules made from this mass and exposed to the air lose weight to the extent of from 16 to 22 per cent., according to the condition of the atmosphere. And if subjected to a very dry air will lose a still higher percentage, but will reabsorb moisture when placed under ordinary atmospheric conditions. This is an important factor, for, if the artificially dried capsule be closed, it will soon show signs of pitting, whereas one newly made, or one which has been kept in a well closed box, will become a firmer and more elegant capsule a day or two after being closed. Capsules made from a mass containing too much water will, on drying, have their capacity materially diminished, and if filled in the

fresh condition become very firm, and put an unnecessarily severe strain upon the joint round the neck of the capsule.

It will be apparent, then, that the most suitable mass is one which loses about 20 per cent. on being exposed to the air, and that capsules not required for immediate filling must be stored in a well closed box.

We now require a water bath to heat the mass, and keep it at a stated temperature while in use. Fig. 1

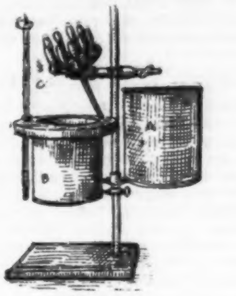


FIG. 1.

shows the parts of such an arrangement. A is a round tin 6 in. wide by 6¼ in. deep, B an earthenware jar, 5 in. wide by 5¼ in. deep, which is suspended in A by a ring of plaster of Paris cast round the neck, the groove in the jar affording a sufficient grip. Through this ring there is a hole bored for a thermometer, which is suspended by an India rubber band to prevent the bulb coming to grief on the bottom of the tin, and if a thermostat is used, it may be let through a second hole drilled in the plaster of Paris, and suspended in the same way.

The most convenient sizes of capsules are 5, 10, 15, 30 and 60 minims, and moulds are required capable of producing capsules containing these quantities when barely full—a full capsule being very difficult to close.

The most elegant shape is flattish oval, and the moulds should be cast with necks not less than an inch long, and sufficiently thick to permit of the easy withdrawal of the capsule. The moulds I have in use, and which serve the purpose perfectly, are cast in block tin. I tried the brass moulder for one size—a 10 minim mould—but in spite of the full instructions he got, together with a pattern, what he sent me were assorted both in shapes and sizes. The advantage of block tin is that one can cast one's own moulds. The metal being soft, the casting is easily dressed by first scraping with a knife and finishing with fine emery cloth. Of course, such work will not compare with the highly burnished article of the brass finisher, but will answer the purpose quite as well.

The moulds are soldered to a circular metal plate, to the back of which is fixed a handle four or five inches long (Fig. 1, C). As the diameter of the plate carrying the moulds is 3¼ inches and that of the jar containing the mass five inches, there is ample room for "dipping" without bringing the moulds into contact with the jar.

In making the capsules about half fill the tin with water, place inside of it the jar containing a quantity of the mass and apply heat until the temperature of the water rises to about 170° F. When the temperature has fallen to about 130° F., the mass will be melted all through, and its surface covered with air bells, which must be carefully skimmed off. The moulds are now rubbed over with a piece of oiled rag, dipped into the mass about half an inch up their necks, slowly withdrawn, and rotated till the gelatine sets. In five or six minutes the capsules are firm enough to be drawn off the moulds, which is easily done by using the finger and thumb for those of the 15 minims and under, and three fingers for the larger sizes.

It is essential to keep a lid on the jar between the "dips" to prevent the formation of a film on the surface of the mass, and the water which condenses on the lid must not be allowed to drop back into the mass, or the capsules will be one-sided or otherwise deformed.

When the temperature falls to 125° F. the bunsen is lighted and the temperature raised to 135° F., this variation not materially affecting the consistence of the mass.

Obviously a mass which has been in use for some time will become a little firmer, and require a higher temperature to produce capsules of the proper thickness. When a thermostat is used, it may be set for 130° F.

Fig. 2 shows a chain of multiplying wheels, the larg-

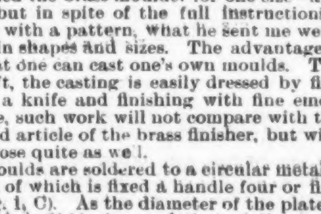


FIG. 2.

est wheel carrying a handle, and the smallest a piece of stout tinplate cut and bent in the form of an air fan. This machine is an efficient piece of apparatus for rapidly cooling the capsules. When the moulds are drawn from the capsule mass and slowly turned in front of the rapidly revolving fan, a very few seconds suffice for the setting of the gelatine. Whereas, if allowed to cool spontaneously, between one and two minutes must elapse before each lot can be set aside.

The capsules have now their necks, or, as they are sometimes called, their tails, cut off with a pair of scissors, and are then ready for filling.

Capsules may be readily filled with any liquid by means of an ordinary male glass syringe. A suitable pipette is attached to the nozzle with India rubber tubing, and the syringe filled with the necessary fluid is mounted in the clamp of a retort stand, as shown at A in Fig. 3. The operator being seated, and the clamp fixed at a convenient height, the empty capsules are held in turn beneath the pipette with one hand, while the piston rod is manipulated with the other. Complete control of the flow is secured by retaining a little air between the piston and the contents of the syringe; the compression of the air effecting a steady flow from the pipette, which may be instantly stopped by raising the piston. Should the piston not fit accurately, this air chamber has the further advantage of preventing any of the fluid getting past the piston, any air which escapes being replaced by an occasional bubble or two drawn through the pipette. As the capsules are filled they are set aside in a vertical position in pill boxes of a suitable size.

It is important, especially when filling oil, to keep the lip of the capsule dry, an "oily mouthed" capsule being difficult to close securely.

Powders can be inclosed in capsules in much the same way as that described for liquids, a small glass funnel taking the place of the syringe. When, however, the powder is bulky and requires packing, the process is both tedious and clumsy and the resulting capsule more or less hard compared with, say, a castor oil capsule. Moreover, the time required for filling such capsules renders it impossible to turn them out at a moderate price. The most expeditious way of capsuling powders is to reduce the powder to the consistence of a thin paste with some inert fluid excipient, and fill by means of a syringe.

For closing the capsules a small water bath, such as is shown in Fig. 3, is required. It is similar to the bath used for heating the capsule mass, B being the tin, and C the pot containing the mass. The skimming from the mass, the necks of the capsules, damaged capsules, etc., may be remelted and used for closing and finishing the capsules. The capsule is closed by gently drawing across its mouth a rather large camel hair pencil charged with the melted mass. If the mass be too hot, the film left by one sweep of the brush will probably be too thin, in which case a second application of the brush is necessary.

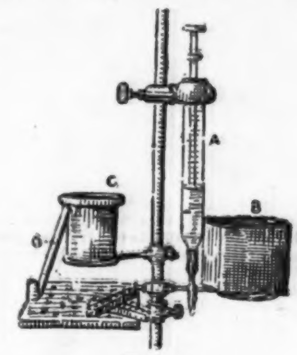


FIG. 3.

The finishing touch is now given to the capsules by dipping them, mouth downward, into a mass made by adding to the ordinary mass about a fifth part of water, and using it at a temperature just sufficient to keep it fluid.

A small ladle (Fig. 3, D)—made by tying the bottom of a test tube to a small wooden handle—is used to lift the mass, and the capsule is dipped into the ladle—about one fourth of the capsule being immersed—and then set into one of the holes in the tray shown at the bottom of Fig. 3. This tray, which may be conveniently made by filling the lid of a tin box with plaster of Paris, and boring holes of a suitable size in the plaster when it has set, is suitable for capsules of 15 minims and upward, but for the 5 and 10 minim sizes narrow plaster supports are necessary (see Fig. 3), so as to allow the edges of the fingers to pass below the surface of the plaster in depositing the finished capsules in one of the holes.

The effect of this final "dipping" is to cover the end of the capsule with a cap of soft gelatine, which, on drying, securely closes the capsule, and gives a neat and elegant appearance to the finished article.

As already pointed out, absorptions of moisture from the atmosphere may account for collapsing or pitting of capsules, and is the only possible cause of pitting in the case of capsules filled with powders, oils, balsam, etc. The pitting usually met with, however, is attributable to the absorption of a portion of the contents of the capsule. This absorption has a twofold action—namely, the passing of more or less of the contents into the substance of the capsule, and the enlargement of the capsule itself, consequent upon such absorption.

When the absorbable material is volatile, the capsule, by exposure to the air, ultimately regains its normal size, and the amount of "pit" is proportional to the quantity of material absorbed. But with nonvolatile material—*e. g.*, glycerine—the amount of "pit" is equal to the amount of material absorbed, plus that due to the permanently enlarged containing envelope.—*The Chemist and Druggist.*

NOTES ON THE COLORS OF MINERALS.

IN the examination of a collection of minerals we find that many of them are colored, for instance sulphur is yellow, cinnabar red, sapphire blue, fluor spar blue, violet, yellow, green, etc.

Now some of these colors are really due to the substance which is the chief component of the mineral; this is the case with sulphur, which element is yellow, and with cinnabar (mercuric sulphide), which in one form is of a vermilion color. But in the case of such as sapphire and fluor spar the color is due to the presence of small quantities of other bodies.

It is to the latter class that I wish to call attention. These minerals have not been systematically investigated as to the cause of their colors.

The following is a list of the minerals which I have up to the present time been able to examine:

EMERY.—Composition $Al_2 O_3$. This substance when pure is white, but it generally occurs of various shades of brown, the color being due to the presence of ferric oxide, which varies in amount from 8 to 33 per cent.

TINSTONE.—Composition $Sn O_2$. When pure is white.

Black.—The black variety is colored by ferric oxide. In one specimen Liversedge found 2·3 per cent. of ferric oxide and 0·8 per cent. ferrous oxide.

Brown.—Brown tinstone is also colored by ferric oxide.

QUARTZ.—Composition $Si O_2$. Often occurs colorless or white.

Rose Colored.—The colour of this variety of the mineral has been attributed to manganese and also to organic matter. Fuchs found in specimens from Robenstein in Bavaria 1 to 1·5 per cent. of oxide of titanium. On examination of several specimens of this mineral it was found that they did not change color or become colorless on heating, showing the absence of organic matter; manganese was also absent in every case. All the specimens contained ferric oxide, and to this body the color is therefore attributed. The presence of oxide of titanium in the rose quartz examined by Fuchs is not sufficient to explain the color.

Violet Quartz.—The color of this mineral, which is known as the common amethyst, has been attributed to the presence of manganese; it has also been stated that the color is due to a ferrate; and Rose found in one specimen 0·5 per cent. of ferric oxide and 0·25 of potassium oxide, which result led him to believe that a ferrate was present in the mineral.

Several specimens of this mineral were examined, and it was found that they became colorless on heating and did not afterward regain their color. They all contained iron, but manganese and organic matter were absent. Owing to the small quantity of iron present it was found impossible to determine in what state it exists in the mineral, but it seems probable that the color is due, as stated by Rose and others, to a ferrate, which becomes decomposed by the action of heat, rendering the mineral colorless.

Yellow Quartz.—A transparent variety of this mineral on heating did not lose all its color, but became of a lighter shade. The color was found to be due to a small quantity of ferric silicate. The color of an opaque variety was due to ferric hydrate, which latter was easily dissolved by hydrochloric acid, leaving the quartz colorless.

Smoky Quartz.—The color of this mineral has been attributed to allotropic modifications of silica, and also to organic matter. A. Foster found that on distillation this mineral yielded a small quantity of a brownish liquid containing ammonium carbonate, and from this supposed that the color of the mineral was due to an organic substance containing carbon and nitrogen.

On examination of specimens of this mineral, it was found that they became colorless on heating, cracking to pieces, and yielded a small quantity of a liquid containing no ammonium carbonate, as stated by Foster; it was, in fact, water. On further examination the color was found to be due to disseminated ferric hydrate, which decomposed on heating, giving up its water.

CARNELIAN.—A variety of quartz.

Red.—The color is due to ferric oxide.

BEELSITE.—A variety of chalcedony. The color of a red variety of this mineral was also due to ferric oxide.

JASPER.—Another variety of quartz, occurs of various colors.

Red.—The color of the red specimens is due to ferric oxide.

Yellow.—Yellow jasper is colored by ferric hydrate.

FLINT.—Many specimens of this mineral were examined; the color of red, brown, gray, and black flint was found to be due to the presence of a small quantity of ferric oxide, and the yellow and brownish yellow to ferric hydrate.

OPAL.—Composition $Si O_2$ with water. When pure, is white.

Red.—A red variety of this mineral was colored by the presence of ferric oxide.

BLENDE.—Composition MS. Pure zinc sulphide is white.

Black.—The color of the black variety of this mineral is due to ferrous sulphide. Various analysts have found iron to the amount of 1·18 to 14·32 per cent. The iron occurs as ferrous sulphide, and thus gives the mineral a black color.

COMMON SALT.—Composition Na Ce. When pure, is colorless or white.

Pink.—The color of a pink variety of this salt was found to be due to a small quantity of manganous chloride.

Red.—The red variety owes its color to inclosed ferric oxide or a reddish clay, which occurs in the salt formations.

FLUOR SPAR.—Composition $Ca F_2$. This substance, when pure, is colorless or white, but as a mineral it occurs in all colors.

Purple Fluor.—The various colors of fluor spar have been attributed to organic matter, and to the molecular structure of the mineral. Schrotter found in the dark blue fluor of Wölsendorf, Bavaria, 0·02 per cent. of ozone, which Schonbein has shown to be antozone, and he gave the name antozonite to this mineral. Schafhäutl found in this fluor 0·02073 per cent. nitrogen; 0·00584 hydrogen; 0·0365 carbon; and 0·08692 chloric acid. Wyrouboff also examined the mineral and found in it 0·0025 carbon; 0·0038 hydrogen, with 0·0180 alumina; 0·0032 ferric oxide; 0·0025 ferrous oxide; and 0·007 of chlorine. Wyrouboff attributes the color to compounds of carbon and hydrogen derived from the water that deposited the fluor spar.

The following results were obtained on examination of several specimens:

On powdering one of the specimens it gave a very peculiar odor, but it was gone instantly. This is somewhat like the one examined by Schrotter, as it is stated that the odor from it is so powerful as to cause headache and giddiness in the miners who work among it.

On heating the mineral gives a very beautiful violet fluorescence, and the fluor becomes first violet and then quite colorless. They all contained manganese,

but no organic matter. The manganese was present as fluoride.

From these results it is difficult to say to what the color is really due. It certainly is not due to organic matter, and the manganous fluoride detected in it, though of a violet color, is not dark enough to give the purple color to the fluor spar. This must be left for further experiment.

Green Fluor Spar also gave a violet fluorescence on heating, and the color was found to be due to a small quantity of ferrous silicate.

Yellow Fluor Spar is colored by the presence of ferric hydrate. On heating, this mineral becomes red.

GYPSUM.—Composition, $CaSO_4\ 2H_2O$. When pure is colorless or white.

Red varieties of this salt are colored by ferric oxide.

WEBSTERITE.—When pure, is white.

Yellowish-brown.—The color of a yellowish-brown specimen was found to be due to ferric hydrate.

CALCITE.—Composition, $CaCO_3$. When pure, is colorless or white.

Yellowish-red.—A yellowish-red variety was found to owe its color to ferric hydrate. On heating it cracks to pieces and becomes brown.

Peachblossom Colored.—The color of this specimen was found to be due to cobalt carbonate.

Pink Calcite.—A pink variety of marble on examination showed that the color was due to manganous carbonate, of which it contained 0·37 per cent. Specimens of this variety of marble have before been examined by Roue, who found 1·13 per cent. of manganous carbonate, and a specimen from Nantlle Valley, Carnarvonshire, contained as much as 8 per cent. of the same.

Black.—Bischof found in a black limestone 1·15 per cent. of ferrous carbonate.

Upon ignition this marble becomes quite white, and the color is due to disseminated carbon, which burns off on heating.

The presence of ferrous carbonate in the limestone examined by Bischof is not sufficient to explain the black color.

ARAGONITE.—Composition, $CaCO_3$. When pure, is colorless or white.

Yellowish-red.—A yellowish-red variety of this mineral was colored by ferric oxide.

Red.—The red specimens are also colored by ferric oxide, sometimes manganese is also present.

SPATHIC IRON ORE.—Composition, $FeCO_3$. When pure, is white.

Pink.—The color of a pink variety of this mineral was found to be due to the presence of a small quantity of manganous carbonate.

Black.—This mineral was found to be colored by the presence of carbon.

WAVELLITE.—Composition, $3Al_2O_3 2P_2O_5 12H_2O$. This body, when pure, is white.

Blue.—Erdmann found in a specimen of this mineral 1 per cent. of ferric oxide. Turquoise is a blue variety of wavellite, and has been examined by Church, who found 2·31 per cent. of ferrous oxide, and 5·27 of cupric oxide, also by Hermann, who found 1·10 of ferric oxide and 2·02 of cupric oxide. The color of the blue wavellite was found to be due to the presence of phosphate of copper. Thus it approaches to turquoise in composition.

SCHORL.—The formula of this mineral is very complicated. The name is generally applied to the black varieties of tourmaline.

The color is due to ferrous and ferric silicates; the combination of the two silicates forming the black color.

MUSCOVITE.—(Common mica.) Composition $K_2H_4 Al_6Si_6O_{24}+H_8Si_{10}O_{22}$. This mineral, when pure, is colorless.

Brown.—The color of this variety was found to be due to both ferrous and ferric silicates.

Black.—The color of this mineral was also due to the two silicates of iron.

LEPIDOLITE.—A variety of mica containing lithuimi, often found colorless.

Peachblossom Colored.—This color is due to the presence of a smaller quantity of manganous silicate.

TALC.—Composition, $Mg_4Si_5O_{14}H_2O$. When pure, is white.

Yellow.—The color of this mineral was found to be due to a small quantity of ferric silicate.

Red.—This variety is colored by the presence of ferric oxide. Treatment with hydrochloric acid dissolves the ferric oxide, leaving the talc colorless.

Black.—Black talc owes its color to both ferrous and ferric silicates.

ACTINOLITE.—Composition (Ca, Mg, Fe), SiO_3.

Green.—It will be seen from the composition of the mineral that it owes its color to ferrous silicate, which is a component of the green mineral.

ASBESTOS.—Composition, $CaSiO_3 3MgSiO_3$. When pure, is white.

Green.—This mineral is colored by the presence of ferrous silicate, which replaces the other silicates to a certain extent.

Grayish-green.—Is also colored by the presence of ferrous silicate.

EPIDOTE.—Formula very complicated.

Green.—This mineral contains ferrous silicate as an essential ingredient; therefore the color is due to that body.

AXINITE.—Formula very complicated.

Grayish.—This mineral was colored by the presence of both ferrous and ferric silicates.

SERPENTINE.—Composition, $MgSiO_3$, $Mg_2SiO_4 2H_2O$. When pure, is white.

Green.—The color of this variety of the mineral is due to ferrous silicate, which varies in amount from 1 to 14 per cent.

Red.—The color of the red variety of serpentine is due to ferric oride.

GARNET.—Formula variable. Pure garnet is white.

Dark-red.—The color of dark-red garnet is due to both manganous and ferric silicates; ferrous silicate is present in some, and perhaps slightly modifies the color.

HYPERSTHENE.—Composition, (MgFe) SiO_3.

Green.—It will be seen from the formula that the color of this mineral is due to ferrous silicate, which is a constituent of the mineral.

STILBITE.—Composition, $CaAl_2Si_6O_{16}5H_2O$. When pure, is white.

Red.—Red varieties of stilbite are colored, owing to the presence of both manganous and ferric silicates, which replace to a certain extent the silicates which are the real components of the mineral.

STEATITE.—Composition, $3MgSiO_3, H_2SiO_3$. When pure, is white.

Bluish-green.—The color was found to be due to ferrous silicate.

AUGITE.—Composition, (CaMgFe) SiO_3.

Black.—The black varieties owe their color to both ferrous and ferric silicates.

FELDSPAR.—Composition, $K_2O, Al_2O_3, 6SiO_2$. When pure, is white.

Red.—The coloring, varying from flesh-red to very dark-red, is due to varying amounts of ferric oxide.

On looking at the results of these analyses, we find that the coloring agents are very few in number, viz., carbon, cobalt salts, manganous salts, ferric oxide, hydrate, and silicate, and ferrous salts. The presence of organic matter other than carbon is very doubtful. The above may be arranged as follows:

Pink colors are produced by manganous and cobalt salts.

Red colors are produced by ferric oxide, manganous and ferric silicates.

Yellow colors are produced by ferric hydrate and silicate.

Brown colors are produced by ferric oxide and silicate.

Green colors are produced by ferrous silicate.

Blue colors are produced by copper salts.

Black colors are produced by carbon, and ferrous and ferric silicates.—*Hardwicke's Science-Gossip.*

FRIENDSHIP OF BIRDS.

WE all know how widespread in the ornithological world is the instinct of sociability, which prompts the individuals of a same species among a certain number of birds not only to emigrate in flocks, but to live in company for the entire year, and to nest thus.

On the contrary, it sometimes happens, especially in a wild state, that two birds (male and female) of different orders seek each other's company and lavish caresses on one another without endeavoring to couple

THE TWO FRIENDS, PARROT AND STARLING.

(physiologically speaking), and, in a word, love one another platonically.

I have had an opportunity of observing such a thing a great number of times between two birds that my mother had kept for several years in one of her aviaries at Rouen. One of them is a female of the genus *Conurus* (*C. jendaya*, Gm.), and the other a male of the genus *Gracupica* (*G. nigricollis*, Payk.) The former is a parrot that inhabits Brazil, and the other, which belongs to the family Sturnidæ, is a native of China and the Indies.

It is curious to see these two beings that ornithological classification widely separates from each other united by ties of friendship. . . . It is well to say that this sentiment exists to a much higher degree in the parrot, who earnestly seeks her companion, follows him to where he goes to perch, presses herself against him, picks his feathers, and, in a word, exhibits a constant friendship for him. As for the starling, although he does not follow up the parrot, he has at least a little friendship for her, for he not only cheerfully allows her to nestle close to him, but he also picks her feathers.

I may add that the starling, by his curious and varied song, and by the queer attitudes that he assumes in executing certain passages of his musical repertoire, justly excites the laughter of those who observe him. This excellent pair of friends is worth the trouble of speaking of in a special publication, and I think that these few lines will not be without interest to those who occupy themselves with ornithological psychology, either from a purely scientific point of view, or solely from a recreative standpoint.

The accompanying figure represents, at about a quarter of their natural size, and in a position that is usual for them, the two birds in question, which I put into a cage so that I could easily photograph them.—*H. G. De Kerville, in Le Naturaliste.*

EARLY LAMBS FOR MARKET.

By GEO. L. GILLINGHAM.

SELECTING THE EWES.

THIS is the first and a very important part. They should be secured early, about the middle of June or not later than the middle of July, and if good pasture is obtainable, they may be purchased even sooner.

Select those with medium tight wool, and under no consideration those with long open wool. We find for this section a grade merino gives the best results, not too much into the merino, as they will be too small and will have difficulty in lambing. But some of the above blood is a decided advantage, as they will drop their lambs earlier, make better mothers, and grow their lambs faster than the coarser breeds. We have always found our first ewes to drop their lambs were of this cross. About one half or one quarter merino is about right. Such ewes can always be found in the drove yard in West Philadelphia at the season of the year above alluded to, and can be bought from $3.50 to $5.00 each, according to the size, supply and demand.

SELECTION AND CARE OF THE BUCK.

He should be of some of the Down breeds. We have always used the Southdown with very good results. Some are now introducing into this section the Hamshiredown and Shropshiredown, but if the ewes are not very large they have difficulty in lambing, as the lambs are larger boned than the Southdown, and it frequently happens that a lamb is lost at birth, and sometimes a ewe. All of which very materially reduces the profits. The Southdown cross, although not as large at birth, fatten as rapidly and are ready for the market as soon as the cross of the larger breeds, without such a strain on the ewe. He should be turned with the ewes at night and kept in a cool, well ventilated pen or stall during the day, not in hearing distance of the flock, where he can remain quiet and be fed on oats and good sweet clover hay, with free access to pure water, being careful not to overfeed on grain, beginning on a half pint and increasing gradually, until he will consume a quart twice daily. He should be allowed the companionship of the ewes until September 1, after which he should be kept from them one month. Thus the last ewe will drop her lamb about February 1, which is late enough for *strictly early* lambs. Some, however, prefer leaving him with them until October 1, thus having the last lamb come about March 1, but this is rather late. After keeping him from them one month, he is again put with them, and a light application of lamp black mixed with oil applied to his brisket, and he will mark all ewes not with lamb.

They by that time having had good pasture, or it being supplemented with a small amount of grain, will be fat enough for the market and can be sold at once, obviating the necessity of keeping them till spring at a probable loss, besides the risk of having them injure the others by crowding, etc. It is a good plan, and one sometimes practiced, to purchase more ewes than you care to winter, as there will be those that will not breed early, and by thus culling you may still have your desired number.

CARING FOR THE EWES.

They should be driven from the pasture and confined in the pen at nights, that they may be safe from dogs.

The pen should be made facing the south, and so constructed as to keep out all cold winds from the north and northwest. Have a small yard connected with it, that they may get the sun in winter. Do not make the inner pen too tight, as it needs to be well ventilated. Their wool is a sufficient protection from the cold if they are kept dry. A good shed with tight roof to keep off rain, open on south side and tight on north and northwest is sufficient. The size of pen to be regulated by the size of flock. As soon as the pasture becomes short in fall, or the ground becomes frozen, they should be confined to the pen and yard and from all cold storms previous to this. The pen should be situated where the surface drainage is good, that the water may be carried away rapidly after a rain. The roof made to shed the water outside the pen, as sheep will not thrive in wet quarters. The troughs for grain should be V shaped, fastened around the sides of the inner pen or shed, sheltered from the storms, high enough from the ground to prevent the sheep from getting into them with their feet, and of sufficient length to give ample room that they may not have to crowd each other while feeding, as this often leads to bad results. These should be *separate* from the hay racks, which should be placed in the center of the pen to enable the sheep to get all around them, and so constructed that they cannot get their heads in them. A good rack is made of slats, nailed up and down about two inches apart, the rack being wider at the top, so the hay may continually drop in reach as it is consumed from below.

Feed liberally on good milk-producing food. What will make a cow milk will also do the same for a ewe. A very good food is composed of oats, corn and coarse wheat bran, about one third of each, beginning with about a half pint, till they will eat about three pints each per day, given in three feeds, with all the good clover hay they will consume. Keep pure water before them at all times. They should be grained some before the lambing season begins, as it will make the ewes stronger, they will have more milk, the lambs will be stronger, get on their feet sooner, and seek the fountain of maternal nourishment, thus enabling them to better withstand the cold we are so apt to have at this season of the year. By feeding grain before lambing, the ewes will require especial attention to keep their udders from becoming caked. They will be found to have an abundance of milk, much more than the lamb will take at first, and will have to be milked out morning and evening until the lamb is large enough to take it all. Under this treatment, the writer has had ewes that required milking for a full week after the lamb was dropped. But even with all this trouble it pays *well* to have them drop their lambs in this condition. The ewes are ready to lay on more fat, or at least hold their own, while suckling their lambs, and be ready to go to market with the lamb, which is another big item on the right side of the ledger, rather than to having to keep her for weeks, and feed her nearly all the profit derived from the lamb to fit her for the market.

THE LAMBING SEASON.

This is the *most important time* and when the most care should be devoted to the flock. The shortest period of gestation for the ewe is 146 days, the longest 161 days, and the average 154 days. Therefore the lambing season may be expected to begin in 22 or 23

weeks from the time the buck was first turned with the flock, although it does not always begin so soon, this being one of the uncertainties of the business.

During this period the flock should be carefully watched, particularly if the weather is very cold. On dropping her lamb the ewe should be caught and the milk started, first removing the small scab on the end of the teat, enabling the lamb to readily supply itself with nourishment, which it will seek to do in a quarter or half an hour from birth, if the ewe has had proper feed and care. In most cases it will be able to start the milk without any help of this kind, but it frequently happens a ewe will milk very hard or have the end of the teat closed so firmly the lamb is not able to start the milk. To be on the safe side it is better to examine all. After the lamb has satisfied its hunger the balance should be all milked out to prevent any trouble resulting from a feverish condition of the ewe, and kept from becoming too full for several days, or until the lamb is able to take it all, as has already been referred to. In case of twins it is safest (particularly if the flock is large) to remove the ewe with her lambs to a small pen or stall till she is sure to own them both. Sometimes while she is devoting her attention to the youngest, the oldest will be able to get on its feet and wander off to another part of the pen and get lost from her; when again brought to her she may refuse to own it, having forgotten it by the other taking her attention. By removing her and giving her less room, the lamb cannot stray off.

Do not be afraid to visit the pen too often. We have found it a good plan to pay several visits during the day, *always* the last thing before retiring and sometimes getting up in the middle of the night, when we thought there would be some new arrivals before morning. We have saved lambs by this means that would otherwise have been lost during a very cold night. When it so happens a lamb is lost, by exposure or any other cause, and another ewe has a pair of twins about the same time, it is a very good plan to put one of the twins to the ewe which lost her lamb. She can be made to own it with a little care. Both lambs will grow faster. Remove her to a small pen with the lamb, hold her for it to feed several times a day, and if she shows no signs of owning it take a dog with you to her pen once in a while. The fear of the dog will arouse the motherly instinct, and she will *naturally* have a desire to protect her young, which will cause her to take more notice of the lamb and own it in a short time.

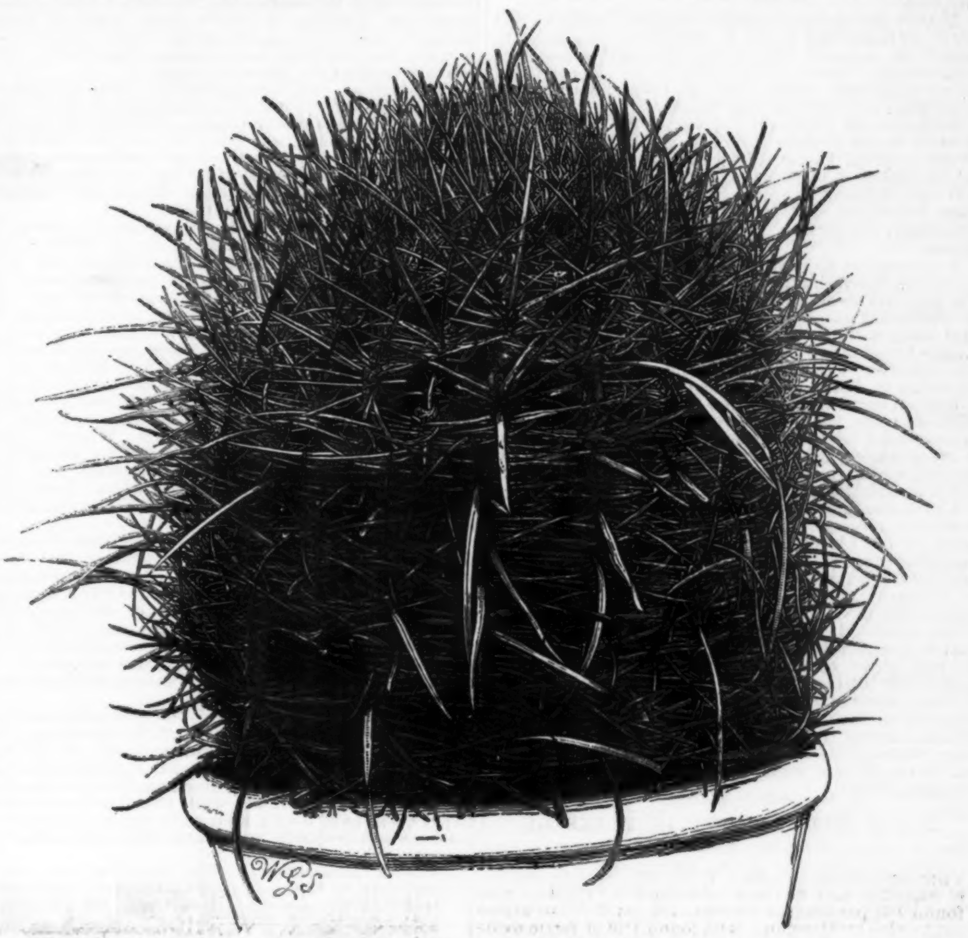
To make the lambs grow as rapidly as possible they should have a small pen adjacent to the main sheep pen, to which they can have free access through a small opening where the ewes cannot get. In this pen keep a trough covered over in such a way that they may get their heads in easily without being able to get in with their feet. In this trough keep at all times a liberal supply of very coarse cracked corn, with all the fine sifted out, as it is apt to get up their nostrils. Also in this pen should be kept a small rack filled with clover heads from the barn floor where the hay has been thrown down. Let this be free from dirt of any kind. They will begin to visit this pen when about a week or ten days old, and after the older ones have found it they will teach the younger ones. You will be surprised how often they will require you to fill up this trough.

By following these directions they should weigh 35 or 40 lb., and be ready for the market (if early in the season) when five or six weeks old. This is a very rapid growth, but the writer has done this well, and in special cases even better. The earlier in the season the lamb is ready, the higher the price and the lighter the weight, and *vice versa*. The butchers will take lambs by the first of February at 35 to 40 lb., and pay sometimes from $8 to $10 each, while by the first of April they will require them to weigh 50 lb., and only pay $5 to $5 50, and occasionally even lower. There have been times in this section when they brought as high as $12, but that day seems to be passed. The price declines so rapidly after the *very early* lambs are ready for the market, leaving such a small margin of profit, that many have gone out of the business.

In conclusion, Mr. Biggle, don't get your ideas up too high, as the greatest difficulty is getting the lambs early enough. But by making a careful selection of the ewes, securing those not too old or too thin in flesh, giving them good succulent pasture, with an addition of a small amount of grain, you may expect a reasonable amount of success. There are many other things in connection with this business that cannot be taught by writing them on paper, but will have to be learned by experience, and will suggest themselves to any careful, observing man, and are so plain the wayfaring man cannot err therein.—*Farm Journal.*

SOME NOTES ON ECHINOCACTUS.

THE genus Echinocactus is represented in Southern California by a great diversity of forms which nearly approach each other. The Cactaceæ are generally recognized as very difficult to study, not perhaps because they are characterless, but because of the difficulty of making specimens, and the usual lack of material for study. Only by very extended and close field observation can one arrive at correct conclusions relative to species and varieties, and this none of our botanists has yet enjoyed.

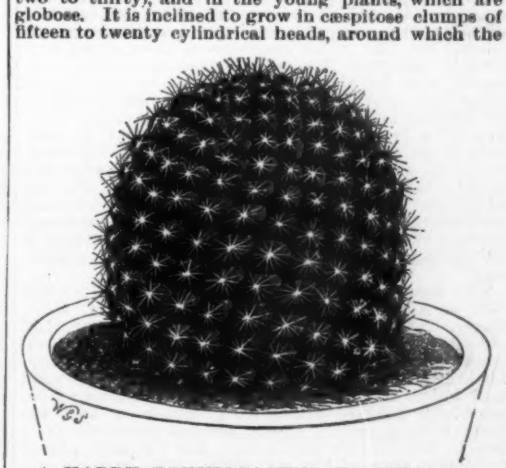


ECHINOCACTUS CYLINDRACEUS.

THE EAGLE'S CLAW CACTUS.

Near San Diego the genus is represented by E. viridescens, Nutt., usually a low, depressed plant of about thirteen ribs, with pale straw-colored flowers and a slightly acid and pleasant fruit. This is a maritime species or variety almost wholly restricted to the immediate neighborhood of San Diego.

Echinocactus Orcuttii, Engelm., is found a little further to the south and further inland from the coast. It differs in size, the number of ribs (usually twenty-two to thirty), and in the young plants, which are globose. It is inclined to grow in cæspitose clumps of fifteen to twenty cylindrical heads, around which the ribs are often spirally inclined. It seems to form almost a connecting link between E. viridescens and E. cylindraceus, Engelm., which was originally collected by Dr. Parry on the eastern slopes of the mountains bordering the Colorado desert, in San Diego County. Dr. Engelmann was at one time inclined to doubt its right to specific rank, as other botanists are still inclined to doubt. In 1882, I found what I determined was this species in the desert canons of Lower California and also west of the mountains near the San Rafael Valley, and Dr. Engelmann wrote that he concurred with me in that opinion. This cactus was a fine cylindrical plant, encompassed by a fine network of its slender, recurving white spines, with lemon-yellow flowers.



A HARDY ECHINOCACTUS, E. SIMPSONI.

Echinocactus Lecontei, Engelm., is another species originally credited to the eastern slope of our moun-

tains and to Arizona. Hundreds of plants annually reach the European market under this name, collected within the confines of the Colorado desert, which differ in only a slight degree from E. cylindraceus. This form is more inclined to a grayish color, less flexible spines, and perhaps to a more globose shape. The demand in Europe for this particular species makes it command a higher price than many others, and it was only recently that I learned whence the trade was supplied.

As they are collected near the original locality cited for it, no blame can attach to those who endeavor to supply the demand. But I must consider it merely a "trade name" for a form differing in no essential character from other plants yearly sent out under this, the preceding, and the following names:

Echinocactus Wislizeni, Engelm., is the oldest name applied to any of these forms of cacti. Some of the plants received under this name are beautiful, with white spines, like those of E. cylindraceus. Others have exceedingly handsome red spines. Still others have dull spines of no special color. In young plants, especially, the color is very variable, as are also the spines.

Echinocactus Emoryi is the last of our Californian species to receive notice. It more nearly approaches the two first mentioned species, the reddish spines and flowers being usually the most characteristic features. But along with the red-spined and red-flowered plants I have found other varieties—white, green, brown, and other shades—until no constant character can be found by which to distinguish between them.

English cacticulturists claim that E. Orcuttii is identical with the old E. Californicus, a name considered synonymous with E. viridescens by Dr. Engelmann. A great variety of plants has reached the European market under the latter name, which, considering its natural variations, is not to be wondered at.

I have carefully studied every form in southern and northern Lower California that I have been able to learn of, and I have been forced to the conclusion that only three true species exist within our limits—E. polycephalus (belonging to a distinct section of the genus), E. Wislizeni, and E. viridescens. Under E. Wislizeni I would class as varieties E. cylindraceus and E. Lecontei; while under E. viridescens I would place E. Emoryi and E. Orcuttii as sufficiently well marked varieties. Several other varieties of both these species could be sufficiently distinguished to satisfy the foreign trade. Perhaps these views will not be retained when I become more familiar with Arizona, New Mexico, and Mexican forms, but they are certainly in line with the later views of Dr. Engelmann, the greatest authority on the family that we have had.—*C. R. Orcutt, in Garden and Forest.*

THE HIGHEST MOUNTAIN PEAKS OF NORTH AMERICA.

IN a communication made to the Academy of Natural Sciences of Philadelphia, at a recent meeting, Professor Heilprin placed on record his barometric determinations of the heights of the four loftiest summits of the Mexican republic—Orizaba, Popocatepetl, Ixtaccihuatl, and the Nevado de Toluca. From these it would appear that considerable corrections will have to be made in geographies of the recorded heights of these far-famed giants of the south. All the observations were made by means of a carefully tested aneroid barometer, and the data computed from almost simultaneous observations made at the Mexican Central Observatory of the city of Mexico, and from barometric readings made at the sea level at Vera Cruz. The equable condition of the atmosphere at the time these observations were made rendered the possibility of the occurrence of possible errors of magnitude almost nil.

Height of Popocatepetl.—The height of Popocatepetl, commonly accepted as the highest peak, was recorded by Alexander von Humboldt in 1804 as 17,720 feet. Several measurements have been made since the date of the trigonometrical observations of the distinguished German traveler, and with results varying from 17,200 feet to somewhat over 18,000 feet. Professor Heilprin's measurements give 17,523 feet, or 200 feet less than the estimate of Humboldt, as corrected by his astronomical associate, Oltmanns. The significant fact, however, is pointed out, that while geographers have almost universally accepted Humboldt's determinations and figures, they have neglected to take account of the newer data which have been made possible through the leveling of the Mexican railway, which was constructed a few years since. These show that the estimate of the elevation of the city of Mexico (7,470 feet) and of the adjoining plateaus, which have served as a basis for most of the angle measurements of the mountains, have been placed 123 feet too high. Allowing for this excess, a striking correspondence is established between the early measurements and those obtained in the spring of the year by the Philadelphia expedition.

The ascent of the peak was made on the 16th and 17th of April by Professor Heilprin and Mr. F. C. Baker, the rim of the crater being reached at 11:30 o'clock on the morning of the 17th, and the culminating point early in the afternoon of the same day. Little difficulty was encountered in the ascent beyond that which is due to the inconvenience arising from the highly rarefied atmosphere. The snow field was found to be of limited extent, and not more than from five to ten feet in depth, and was virtually absent from the apex of the mountain. The surprisingly mild temperature of the summit, 45 degrees Fahrenheit, rendered a stay of several hours in cloudland very delightful.

The Mountain of Orizaba.—With regard to the elevation of what is commonly supposed to be the second highest summit of the Mexican republic, the peak of Citlaltepetl or Orizaba, the results of Professor Heilprin's determinations show more marked variations from those of most of the earlier investigators, and more particularly from those of Humboldt. The latter determined the height of the mountain, by means of angles taken from near the town of Jalapa, to be 17,375 feet, while a still earlier determination by Ferrer, in 1796, and recorded in the transactions of the American Philosophical Society, gave 17,879 feet. The latter estimate has been generally adopted by German geographers, and Humboldt himself has considered it more nearly representing the truth than his own measurement. The Mexican geographers, on the other hand, have adopted the measurement of Humboldt, or that which was obtained by the national commissions of 1877, and which indicated a height of 17,664 feet.

Professor Heilprin, with three of his scientific associates and eleven guides, made the ascent of the mountain on the 6th and 7th of April, or ten days before the ascent of Popocatepetl. The last camp, at a height of some 13,000 feet, was left shortly before five o'clock in the morning of the second day, and after a difficult and continuous struggle of twelve hours through loose bowlders, sand, and a much cut up ice cap, the party—or rather the fragment which succeeded in holding out—finally reached the rim of the crater.

A photograph was here obtained of the depression which marks the summit of this most symmetrical cone of the North American continent. Professor Heilprin's measurement, which was made at a point about 120 feet below the apex of the cone, indicates a total height of the mountain of 18,206 feet, or some 325 feet in excess of the measurement of Ferrer, and upward of 800 more than that of Humboldt.

The equal conditions of the atmosphere under which the measurements of both the peaks of Orizaba and Popocatepetl were made, and the fact that the two measurements were made with the same instruments, after an interval of only ten days, appear to leave but little room for doubt that the latter determination is within close limits the correct one. There thus seems no question but that the first place among Mexican volcanoes must be accorded to the "Star Mountain."

The sense of excessive fatigue which marked the ascent of this mountain as compared with that of Popocatepetl was considered in itself a sufficient index of the much greater elevation. Messrs. Witmer Stone and F. C. Baker, two of Prof. Heilprin's associates, were compelled to desist from the final attack upon the mountain when not more than some 300 feet below the summit. Mr. Le Boutillier's strength failed him at an elevation of about 14,000 feet.

As upon Popocatepetl, the snow cap upon Orizaba, although arising 2,400 feet, or nearly half a mile, above the summit of the highest peak of the Alps, was a comparatively insignificant development. Only a quarter of an hour was passed on the crest of the mountain when the difficult descent through the numerous *seracs* of the ice was made. The camp was reached a little after eight o'clock in the evening, thus completing a remarkable round of mountain climbing of fifteen successive hours.

The views from the slopes of the mountain are described as being surpassingly grand, far exceeding anything that Prof. Heilprin had hitherto seen in his travels. Far off to the west the giants Popocatepetl and Ixtaccihuatl were clearly outlined against the sky at a distance of about 100 miles, while to the east and south the eye wandered over a seemingly endless expanse of plateaus and lowlands, penetrating through a series of successive cloud planes.

Ascent of Ixtaccihuatl.—The ascent of the third highest peak of the republic, Ixtaccihuatl, was made on the 27th of the same month on which the two other ascents above noted were also made. In its general features, this mountain differs broadly from the two peaks before mentioned. Although the remains of a volcano, it no longer presents either the symmetry or conical outline of its more famous rivals. A strong, flowing crest, covered with a heavy deposit, some 75 or 100 feet in thickness, of snow and ice, serves readily to distinguish the familiar "White Woman" of the plain of Anahuac.

Above what is now the highest point there at one time arose the crater wall, but the destruction through natural causes of the summit has completely obliterated all traces of both the crater and wall. The heavy cap of snow, a true *firn*, or *nevé*, feeds one or more glaciers which descend the western slopes. Across one of these glacial ice sheets, whose nature was now for the first time made known to the Mexicans, the dangerous ascent was accomplished. Huge crevasses at short intervals barred the progress of the march, but the point, estimated to be about 75 yards below the summit, was reached about 10:30 o'clock in the morning. Two impassable crevasses, cutting the crest of the mountain at right angles, prevented a nearer approach to the apex.

Prof. Heilprin's measurements determined the height of this mountain to be 16,962 feet, or from 800 to 1,300 feet above that which is accorded to it by Mexican geographers. This determination, on the other hand, accords very closely (within 11 feet) with the very careful, but now generally overlooked, trigonometrical measurements made in 1857 by Sonntag, under the auspices of Baron von Muller.

It is difficult to account for the low value of the height of this mountain given by Humboldt and the Mexican geographers, in view of its close proximity to Popocatepetl. So nearly do they appear of equal height that the eye at first fails to distinguish which of the two summits is the highest. German geographers, however, in a few cases, have adopted Sonntag's measurements, neglecting, however, as in the case of Popocatepetl, to make allowances for the error, in this case of 125 feet, which is indicated by the leveling of the Mexican railway.

The temperature on the summit of Ixtaccihuatl was found to be much lower than on either of the other peaks, being 32° Fahrenheit.

Ascent of Nevado de Toluca.—The fourth highest summit of the republic, the Nevado de Toluca, was ascended by Prof. Heilprin and Mr. Baker on the 25th of April. This mountain, owing to its lesser elevation, has a much easier ascent than the others. In fact, it can be ascended by horseback to within about 600 feet of the apex. The rim of the broken crater is extremely ragged and narrow, descending with almost equal abruptness to the inner and outer faces of the volcano. At some points the crest is so attenuated that it can be readily straddled. This feature recalls the famous Polnischer Kamm of the Carpathian Mountains, which Professor Heilprin ascended in 1878, and from which there is obtained a precipitous descent on the one side into Gallicia and on the other into Hungary.

The barometric determination of the Nevado de Toluca gave a height of 14,952 feet, and gave approximately the mean between the determination of Humboldt and those of a class of students from the School of Engineers of the city of Toluca.

In regard to the position which the peak of Orizaba holds to the mountains of the North American continent generally, it may be said that its only rival without the Mexican domain is Mount St. Elias, situated on approximately the 141st parallel of latitude, and whose summit is claimed both by Great Britain and the United States (Alaska) as their possession.

So broadly divergent, however, are the results of the measurements of this mountain that as yet it has been impossible to obtain even remote concurrence in the views of geographers. Thus the early measurements of La Perouse, made in 1786, give less than 13,000 feet.

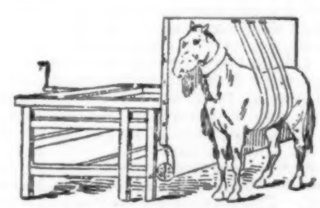
The British Hydrographic Chart of 1872, with its data borrowed from still earlier charts, gives 14,970 feet, and this estimate is the one which is generally followed by the English and a number of American geographers. Malespina in 1791 determined the height by means of angles, taken from near the position of Fort Mulgrave, to be 17,851 feet, which figure is reduced by Tebenkoff by somewhat more than 900 feet.

The most recent carefully conducted series of measurements are those which were made by Mr. W. H. Dall, under the auspices of the United States Coast Survey, in 1874. These yielded results ranging from a little more than 18,000 to nearly 20,000 feet. The measurements were made from distances of 69, 127, 167 miles, and it is more than likely that the discrepancy in the results obtained is due to the very small angles of measurements, and to an uncertainty regarding the actual position of the mountain.

The extreme variation of nearly 2,000 feet in a mountain less than four miles in height renders the correctness of the determinations extremely doubtful. With little doubt Mount St. Elias is considerably more elevated than appears on many of the English and German maps (14,975 feet), but in how near it approaches the height of the Mexican volcanoes is still a question for future solution. The existing evidence seems to point to the "Star Mountain" of Mexico, the peak of Orizaba, with its 18,200 feet, as the culminating point of the North American continent.—*Philadelphia Ledger.*

IMPROVED OPERATING TABLE FOR ANIMALS.

A NOVELTY in veterinary surgery has been successfully performed by Dr. L. A. Anderson, in his hospital. The remarkable feature of the operation was the



THE TABLE TOP TILTED.

READY FOR THE OPERATION.

table and its appliances, by which a sixteen-hand draught horse, weighing 1,200 pounds, was so secured that during the operation, which lasted only eight minutes, the animal moved not a hair's breadth.

The table is of solid oak, and rests on a stout platform about two feet high. By means of a crank operating on cogs, the table on which the animal lies is made to move slowly upward and downward; the horse, led alongside of the table in an upright position, is securely fastened to it, and then the horse and the table lowered until the animal is lying so as to be operated on with ease.

The horse could barely walk, the spavin on the off hind foot causing such agony.

The animal was led alongside of the table, and a stout inch rope fastened to the front of the table was held around the animal's legs by an attendant. The three four-inch wide surcingles were then strapped securely, tying the animal alongside of the table. The head was then fastened to the table, and it was slowly lowered to a horizontal position.

The animal at first struggled, but once on the table lay as meek as a lamb. The feet were securely fastened by stout straps to the table, the additional precaution being used of tying the left hind foot with an inch rope.

The operation is known as cuneon tenotomy, and was first proposed by Prof. Lafosse to abolish lameness arising from bone spavin. It requires the division of the internal or cuneon branch of the tendon of the flexor metatarsi. The tendon that gave the trouble is a stout one, a branch of another tendon. It starts from the anterior portion of the hock and runs across diagonally downward to where the curb generally occurs.

The doctor first made an incision an inch long, and a probe-pointed instrument was inserted and the tendon raised and cut, which gave instant relief. The tendon lay in a groove and was readily found. A bony tumor was growing under the tendon, making the tension on the tendon so great that the animal could not put its foot to the ground.

Five minutes after the operation the horse was eating hay, and an hour afterward was walking, with many signs of improvement.—*Cincinnati Enquirer.*

A NEW FORM OF SPRENGEL PUMP, AND APPARATUS IN CONNECTION THEREWITH.

By SIDNEY G. RAWSON, D.S.C., F.I.C., Demonstrator of Chemistry, University College, Liverpool.

ANY one who has used an ordinary Sprengel pump will know that the gas from the vessel which is to be exhausted is removed by small pistons of mercury. These rapidly succeed one another in the barometric fall tubes, and portions of the gas are trapped, and carried away between each two of these pistons. When the exhaustion is approaching completion, the volumes of gas so removed become exceedingly small, and the last portion of the process is then one of increasing slowness. The newer forms of pumps work on another principle. The mercury in them is caused to issue in the form of a fine jet or spray, and the molecules of the gas are, as it were, driven forward and caught by the mercurial bombardment to which they are subjected. They are then trapped by the pistons of mercury which form in the ordinary way lower down in the fall tubes.

This form of pump is divisible into two main kinds, viz., the one in which the jets of mercury issue in a horizontal plane as figured in Gimingham's paper (this *Journal*, III., 83), and the other in which the mercury flows from the commencement in a vertical direction, as in Fig. 1.

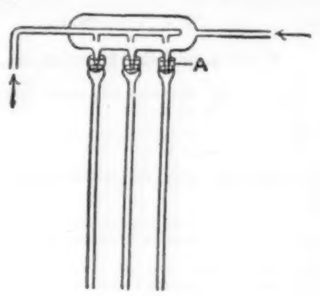


FIG. 1.

Of these two modifications, I prefer the latter, and for these reasons: If mercury issues horizontally, it is somewhat difficult to so place the jets that the streams of mercury shall exactly impinge on the mouths of the tubes. Unless the pump is well made, they will either strike too high or too low, and further, unless there is a considerable pressure of mercury, the jets may not carry even so far as the bounding walls of the exhaust chamber. Then the lowest tube receives an excess of mercury and becomes choked.

In the second form of pump, if the fall tube is slightly opened at its origin, the mercury can only run down that fall tube opposite to its own supply jet. This latter form is also more readily made, and especially is this the case as the number of fall tubes increases. The peculiar mercury distributer of this pump we owe to Nicol, though it had been used by myself some time before the publication of his paper in the British Association Reports for 1887.

My own form of this pump differs somewhat from Nicol's in the following respects. I seal the fall tubes to the pump head, and use no India rubber as a connection (see Fig. 1, A), thus doing away with all chance of leakage. The mercurial supply tube, within the exhaust chamber in his pump, ends freely, and in the same horizontal plane with it is the exhaust tube. This, to my mind, would impose rather a strain on the tube from the leverage of the mercury, and I have therefore always sealed the tube to the wall (Fig. 2, A), and so placed my exhaust tube, B, that it opens in from above. The fall tubes are also sufficiently long to enable me to collect the gases which are exhausted. All these are, however, minor differences.

It will be found that if a pump has been working for some time, the fall tubes always become coated inside with a thin film, possibly of oxides of foreign metals. The mercury which I use I have had distilled two or three times, and one would feel inclined, therefore, to say that it was quite pure. But even with this pure mercury the deposit, though it formed very slowly, always made its appearance in the end. Small air bells

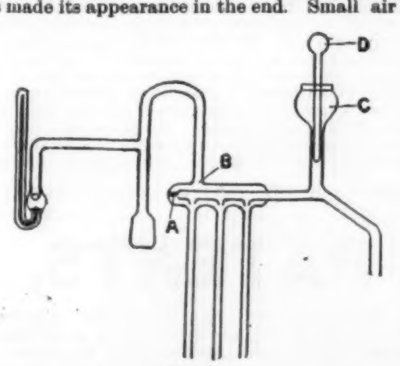


FIG. 2.

or bubbles cling most obstinately to this film, and hence it becomes a matter of some importance to be able to remove it easily, and without stopping the pump. For this purpose the small funnel, C, is attached to the pump. Usually this is kept filled with mercury, but, when necessary, a little sulphuric acid is poured on the mercury, and the plug, D, which is ground in, is gently raised, and the mercury, together with a portion of the acid, is allowed to run into the distributer, and thence into the fall tubes. The plug is replaced, and a little more mercury poured in. I have found sulphuric acid very good for this purpose. Professor Ramsay recommends the use of the vapor of glacial acetic acid as a cleansing agent.

This pump is a very excellent one and of great power. If only three fall tubes are required their free ends can be easily bent up so that they shall all deliver their gas together; this becomes more difficult as the number increases, but if more exhaustion be required other tubes can be added with ease.

While experimenting with this pump I devised the very simple form which is shown in Fig. 3. A piece of ordinary pump tubing some 50 inches in length is taken, and about 10 inches from the one end a small bulb is blown. There is then sealed in this and projecting into the cavity a small glass jet, about a quarter of an inch in length and of exceedingly fine bore, with the nozzle pointing inward. It will be noticed that while in the other forms the feed jets of mercury are detached from the fall tubes, here each fall tube carries its own jet, the arrangement being very compact.

The rate at which the feeding jet will supply mercury entirely depends on the depth of the mercury in the exhaust chamber, and therefore on the length of the

FIG. 3.

tube lying above the bulb. By regulating this depth the pump can be caused to work more or less rapidly as may be required, and this without any contrivances in the shape of taps, etc. There is further a very thorough division of the mercury in the little trapping bulb, for the fine jet of mercury, which is under considerable pressure, impinges strongly on the opposite wall, and is there broken up, filling the bulb with a shower of mercury drops. Possibly this effect might be increased if two feed jets were sealed into the bulb. I have found it more advantageous to replace the piece of pump tubing above the bulb by some of considerably wider bore and thinner walls; the difficulties of exhaustion are increased if the molecules of gas have to travel along capillary tubes.

Though two or three fall tubes of this description can be sealed into a glass exhaust chamber, it is a somewhat difficult task. Unless an extreme amount of accuracy in the volume of gas to be collected is required, it is quite sufficient to take a piece of wide glass tubing which is strangulated at either end so as to firmly hold the rubber corks with which it is to be closed. Through the lower cork passes the pump and fall tube combined, and through the upper the mercury feed supply and the exhaust tube. From some experiments which I have made I agree with Gimingham (*loc. cit.*) that the diameter of the bore of the fall tubes should be about 1·6 mm., and the length about

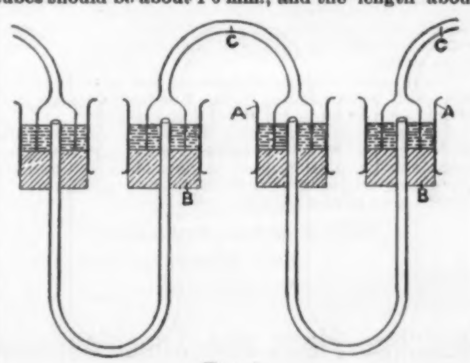


FIG. 4.

1 meter, reckoning from the level of the mercury in the lower reservoir to the mercury feeding jet. In longer tubes than this the mercury falls with much force, and the incessant hammering which goes on is apt to cause the tubes to crack; several have been thus rendered useless in my hands.

In working with exhaust pumps there is usually some difficulty in making an air-tight joint between the pump and the apparatus which is to be exhausted. Of course, the most effectual and certain way is to unite the two ends by an actual glass seal, but in many cases this is by no means easy, and when made successfully it has the disadvantage of converting all the different portions into one solid, rigid whole. Professor Crookes uses very thin spiral glass tubes to unite the various pieces, and these, from their elasticity, do allow of there being a certain amount of play, but the glass seal, and with it considerable experimental skill, is still required.

India rubber tubing is of very little or no use. All sorts of cements have been tried for this purpose. Professor S. Thompson* mentions a mixture of Burgundy pitch, 96 parts, with 4 parts of gutta percha or one part of vaseline with 8 parts of paraffin wax. Others are equal parts of beeswax and resin, India rubber and many more. I have myself used beeswax and resin, containing a little vaseline, but I cannot recommend it highly, though it is as good as any of the others. Paraffin wax, pure and simple, I have also tried and found to work well, but it contracts on solidification, and attaches itself more especially to the glass walls, leaving a fissure between when these are close together, and hence there is always the chance that air may get in. No organic compound can be said to be good, as at high vacua they all evolve vapor. As suggested by Professor Thompson in his paper, some experiments were made by me on fused chloride of lead. This only melts, however, at a high temperature, somewhat below a red heat, and at the same time emits fumes. On cooling it contracts considerably and cracks in all directions.

After trying many materials, the following is the cement I now employ, and which is of very easy application. It is nothing but fusible metal containing a con-

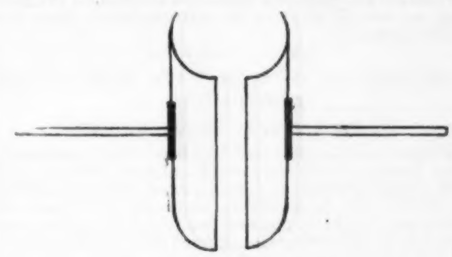


FIG. 5.

siderable amount of mercury. Its percentage composition is as follows:

	Per cent.
Bi	40
Pb	25
Sn	10
Cd	10
Hg	15

If ordinary fusible metal be taken, it will crack the glass, from the large amount of expansion which it undergoes on solidifying. The addition of a little mercury reduces its expansibility and at the same time lowers the melting point. As it still, however, expands considerably on cooling, it forces itself into every minute crevice, acting as a most efficient cement. It should be applied in a molten condition, and the glass should also be hot, and, before exhausting, the joint should stand for an hour to allow the alloy to become thoroughly set. Tubes cemented to the pump by this compound I have had exhausted for weeks without any sign of leakage. I wish here to express my thanks to Mr. H. S. Marsh for the trouble which he has taken in experimenting with me on these alloys.

I also employ a special form of joint. It is shown in Fig. 4 as in use between two U-tubes which have been taken for drying the gases which are to be collected. Each limb bears a small glass cup, A, carried on a cork, B, through which passes one end of the U-tube. A curved tube, C, bell-mouthed at either end, fits in each case outside the free end of the tube but within the glass cup. The molten alloy is poured in almost to the level of the mouth of the U-tube, and on cooling grips the whole firmly together. Until the alloy is poured in there is any amount of play, as can easily be seen, between the different parts of the appa-

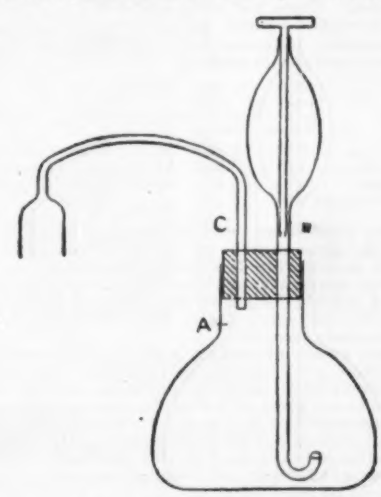


FIG 6.

ratus, for the bell tubes need not be placed in position until everything else has been finally adjusted.

Moreover, instead of there being a long stretch of U-tubes or other apparatus, these can be ranged in rows of twos or threes, etc., one behind the other, by placing the proper bell tubes at right angles to the others in that row, and thus making connection with those coming both before and after.

The apparatus can readily be disconnected by placing round each of the glass cups in turn a brass cup riveted to a rod of the same metal. When the rod is warmed the brass cup rapidly becomes heated and the alloy, as it melts at such a low temperature, is easily

* "The Development of the Mercurial Air Pump." *Journal of the Society of Arts*, 1888. From this paper Fig. 1 is copied.

liquefied, and the bell tube can then be lifted out. It will be found more convenient to have the brass cup in two halves attached to two brass rods as in Fig. 5; it is then more easy to remove it. Otherwise, as it must fit close to the glass cup, it will be necessary to wait until the brass cup is cool before it can be bent open.

In some experiments on which I am engaged I have found it necessary to use a particularly formed flask for the preparation of certain gases. A short description of this may prove interesting.

It holds about 200 c. c., and fitting to the neck and ground to it with the *greatest care* is a glass hollow stopper, A, perforated in two places. For cement I use a mixture of beeswax, resin, and a little vaseline. Through one perforation, B, in the stopper passes an inlet tube for acid, terminating within the flask in a tube bent up slightly on itself. Outside the flask it bears a glass bulb into which the acid can be poured; the bulb is choked by a ground glass rod, cut into which is a slot corresponding to one in the bulb. When the slots coincide the acid passes down, but by turning the glass rod through 180° the connection is cut off. A little acid should always be left in the bulb. Through the other perforation, C, passes the exit tube, terminating in a bell mouth.

The whole apparatus, from pump to generating flask, it will be observed, is without a single tap of any kind, is air tight, and yet is readily put together and disconnected, and requires, except in the case of the glass flask, no special skill in its manufacture.—*Jour. Soc. Chem. Industry.*

EXAMINATION OF OILS, FATS, AND ALLIED SUBSTANCES.

By THOMAS T. P. BRUCE WARREN.

WHEN two oils are mixed together which separately yield insoluble products with sulphur chloride, it is found that this reagent exerts a *selective* action, so that one of the oils is relatively more affected than the other, and I have no doubt a fractional separation may be made by adjusting the amount of chloride required for the quantity present of the more active oil. The quantity of soluble matter yielded by a magma to carbon disulphide, or removable by boiling in a solution of caustic soda, will depend on the amount of chloride used, and also on the nature of the oils themselves.

Castor oil yields a small proportion of soluble matter and is so energetic in its action that we are obliged to dilute the chloride so as to moderate its effect. Rape oil or any similar oil, if used to dilute the castor oil, will only slightly modify its action; the effect of this oil is to deprive the rape oil of its allotted proportion of chloride and to become itself more firmly solidified; hence, when the magma is treated with CS_2, the soluble portion will be proportionately richer in rape oil products as the quantity of castor oil is increased.

When the *yellow* chloride of sulphur acts upon an oil the chlorine is chiefly evolved as HCl, while the sulphur combines simultaneously with the dehydrogenized portion of the oil. I cannot speak definitely of what happens with those oils which do not yield insoluble products. The estimation of sulphur and chlorine retained in these purified insoluble products will assist us in many ways, so that I hope to supplement this part of the subject at an early date.

The total weight of the *dried* solid magma formed by sulphur chloride should always be noted, as it not unfrequently gives us an important insight into the nature of the substances we are dealing with; but a far more important clew is to be gained from the subsequent treatment with solvents—5 grms. lard gave 5·80 grms. solid magma, which was entirely soluble in CS_2. This lard was prepared from the "flare" of the pig, under my own supervision. The iodine absorption was 52·6 per cent. I hope to obtain some purified lard oil from the same source at some future time, but the significant fact proved here is that lard oil should yield no insoluble product if pure.

The same quantities of lard and lard oil and chloride were used. Cocoa nut oil is added to show the differences in weight yielded by fats giving no insoluble products and adulterated oils containing an oil which gives an insoluble product.

	Sulphur Chloride. Total weight, grms.		Iodine Abs., P. c.		Remarks.
	Magma.	Soluble.	Original oil.	Extract from magma.	
Lard	5·80	5·80	52·6	47·40	Own rendg.
Lard oil......	6·25	0·75	93·2	48·58	American.
Lard oil.......	6·19	0·48	89·9	52·06	English.
Cocoa nut oil.	5·14	5·14	..	14·70	

These results are very instructive. The iodine absorptions show that the oils or fats which yield *no* insoluble products are but little altered by chloride of sulphur, whereas a mixture of such an oil or fat will yield a soluble portion totally different in its iodine absorption and more closely approaching that of pure lard similarly treated.

Again, an oil or fat which is not solidified by chloride of sulphur gives an increase in weight very different from oils yielding insoluble products, and the portion thus removed gives an iodine absorption quite unlike the original oils or mixtures. A mixture of cocoa nut oil and cotton seed oil may be put together having a low iodine absorption, but this treatment would at once reveal the nature of the mixture, as the cocoa nut oil would be removed by CS_2.

Lard oil, as used for lubricating, may be put together in two ways; animal fatty matter may either be added to cotton seed oil or the stearin from cotton oil may be in excess of what the oil naturally contains, and this may be added to animal fat, but by refrigeration and pressure we may recover the olein, when the iodine absorption of the substance left on the filter, as well as that of the olein, will help us to a solution of the problem. Animal fats or oils do not blend so intimately with vegetable fluid oils.

As regards lubrication, I do not suppose that there is much to complain of in this mixture, but when we pay £40 per ton for an article consisting mainly of an oil which can be bought for £20 per ton, the financial aspect is at least discouraging.

Bearing more directly on the chemistry of fatty bodies, and more particularly on the oleic and stearic glycerides, I may say that I am driven to the conclusion that chloride of sulphur shows us that we cannot regard these compounds in animal and vegetable oils and fats as having an identity of composition. Oleic and stearic acids from animal fats and concrete oils, when separated and purified, and subsequently converted into glycerides, behave as the original oils and fats, but if stearic or oleic acids be separated from cotton oil, or any similar oil, and subsequently converted into their corresponding glycerides, they behave with chloride of sulphur as before separation.

I was inclined to believe that this difference was due to the presence of some modifying constituent in certain oils or fats, or to a deficiency of glycerin; for the presence of this latter body is essential to the reaction. The probable expulsion of the glycerin will not account for the apparent anomaly in the behavior of these acids.

This portion of the subject seems so important that I propose to re-examine the whole matter more minutely, so as to include the details in these papers.

The experimental case is briefly this: A mixture of cotton seed oil and lard was saponified, the fatty acids separated and reconverted into their corresponding glycerides, and purified by recovery from CS_2 solution. This mixture showed no difference when treated with chloride of sulphur. The cotton seed oil and the lard had each recovered their own individuality as before.

The practical deduction is that a mixture of oils may be so completely altered by time, exposure, or other accidental causes, that identity of its original composition seems hopeless. The mere loss of glycerin need introduce no embarrassment.—*Chem. News.*

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